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Vol. 28 MAY, 1936 No. 5

DIVERSIFIED ELECTRIC RATES AND THEIR APPLICATION TO WATER COMPANIES

By Nathan B. Jacobs

(President, Morris Knowles, Inc., Pittsburgh, Pa.)

The rates charged by electric utilities are of interest to the water works executive from two points of view. First, the water utilities are purchasers of electric service for lighting, driving motors to run pumps, dry feed machinery, agitators, softening equipment, etc. As a seller of public service, the water works executive is interested in the electric schedules as a model for the type of charge he should make for the service which the water utility renders.

WATER RATES

In the development of its system of charging, water utilities first adopted a flat rate basis, depending upon such elements as: (1) the assessed valuation of property; (2) the number of rooms in the house; (3) the number and type of fixtures installed; and (4) rather arbitrary lump sums, dependent upon the kind and type of industry involved.

With the development of metering came a charge based on the quantity of water supplied, measured in either gallons or cubic feet. Other utilities went through very much the same process. Natural gas, for example, was charged for on the basis of the number of rooms; lighting on the number of fixtures. However, these utilities,

like water utilities, found metering desirable both as a conservation step and also as a method of more equitable charging for the service rendered. Water rates have become more or less standard and have been either a two-part or one-part rate. In case of a two-part rate, the readiness to serve charge, generally varying with the size of the meter, comprises both the demand element and the customer cost, and the output charge represents those elements which vary more or less directly with the quantity of water furnished, the schedules being divided into blocks, the charge for each block decreasing with the quantity used. The old schedules, often referred to as "saw tooth," wherein all of the water is purchased at a given rate depending upon the quantity, have generally passed out of use.

In general, water utilities have only one meter schedule. The schedule is flexible enough and of universal application so as to apply to all customers from the smallest home to the largest industry. Very often, it has been so arranged that all of the demand and customer elements are absorbed into the early blocks of the schedule. Generally, it is necessary to protect the demand charge on large meters by a "minimum." However, the present depression has shown the futility of the minimum charge, where large industrial plants which are not using enough water to equal the minimum are ordering smaller meters installed, and in cases of shut down for a period of longer than a month, have been ordering the meters out.

In a recent paper before the American Water Works Association, the writer called attention to the hopeless task which some municipalities have found in trying to compare their water rates with other communities. Where the system is metered, rates can be compared by assuming a relation between the size of meter and the average consumption. This is necessary because of the great variation in the percentage of the revenue allocated to the readiness-to-serve and minimum charges and that which is in the output charge itself. For the purpose of making such comparison, figures 1, 2, 3 and 4 have been prepared. These diagrams show the general relation by reducing all of the schedules to an average cost per thousand gallons obtained by adding the output charge to the readiness to serve charge, subtracting the discount, if any, and dividing by the quantity of water used. In order to make these comparable, all have been reduced to a monthly basis, those having quarterly or semi-annual rates have been computed on the basis of the published rates and divided either by 3 or 6 (months). The schedules used were those available

as of the date shown on each diagram. No attempt has been made to correct these diagrams because of any change in rates promulgated by the utility subsequent to the dates shown.

The general similarity between the resultant charges is particularly evident on the diagrams of the Pennsylvania groups, both the pri-

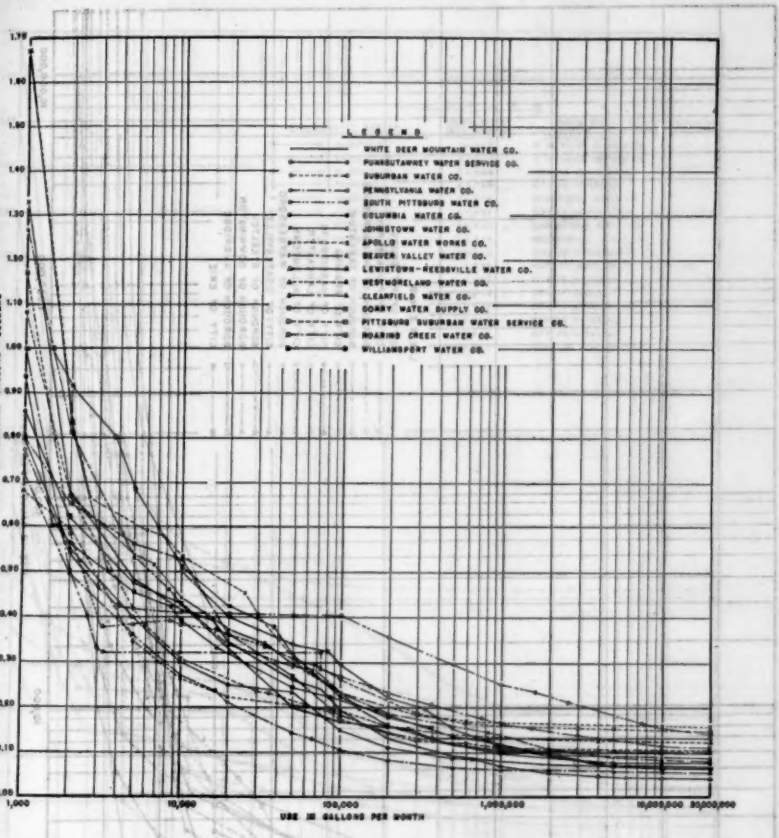

FIG. 1. COMPARISON OF NET COST OF WATER PER THOUSAND GALLONS
Based upon tariffs of various Pennsylvania utilities

vately-owned companies, shown in figure 1, and the municipally-owned plants, shown in figure 2. The rates charged for the first thousand gallons a month are controlled almost wholly by the readiness-to-serve or minimum charge. The effect of the readiness-to-serve charge is minimized as the use of water increases, so that on the right hand side of the diagrams, the effect is practically negligible.

FIG. 2. COMPARISON OF NET COST OF WATER PER THOUSAND GALLONS
Based upon tariffs of various Pennsylvania municipalities

In the West Virginia group, which comprises both privately-owned companies and municipally-owned utilities, the similarity is not so evident, due no doubt to local conditions, and particularly to the range in size of communities running from less than 2,000 population to over 60,000.

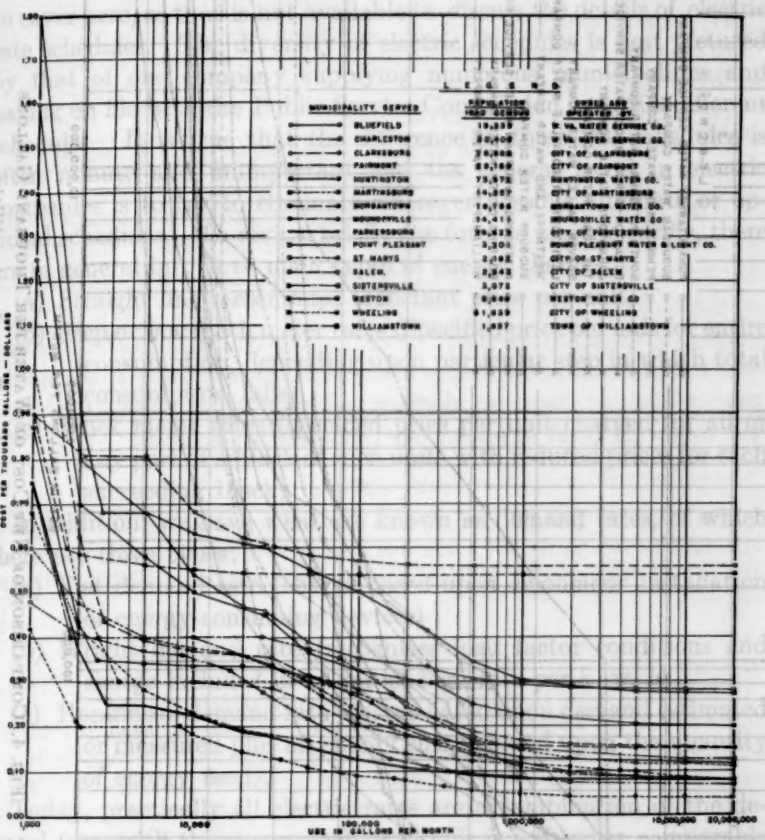

FIG. 3. COMPARISON OF NET COST OF WATER PER THOUSAND GALLONS
Based upon meter tariffs of various West Virginia utilities and municipalities

In figure 4, the rates are only shown for the commercial and industrial group, ranging from 10,000 gallons per month up. The scale has been changed so as to show the variations in greater detail. With but few exceptions, all of these charges seem to follow the same trend. With this general explanation of the trend of meter rates, it

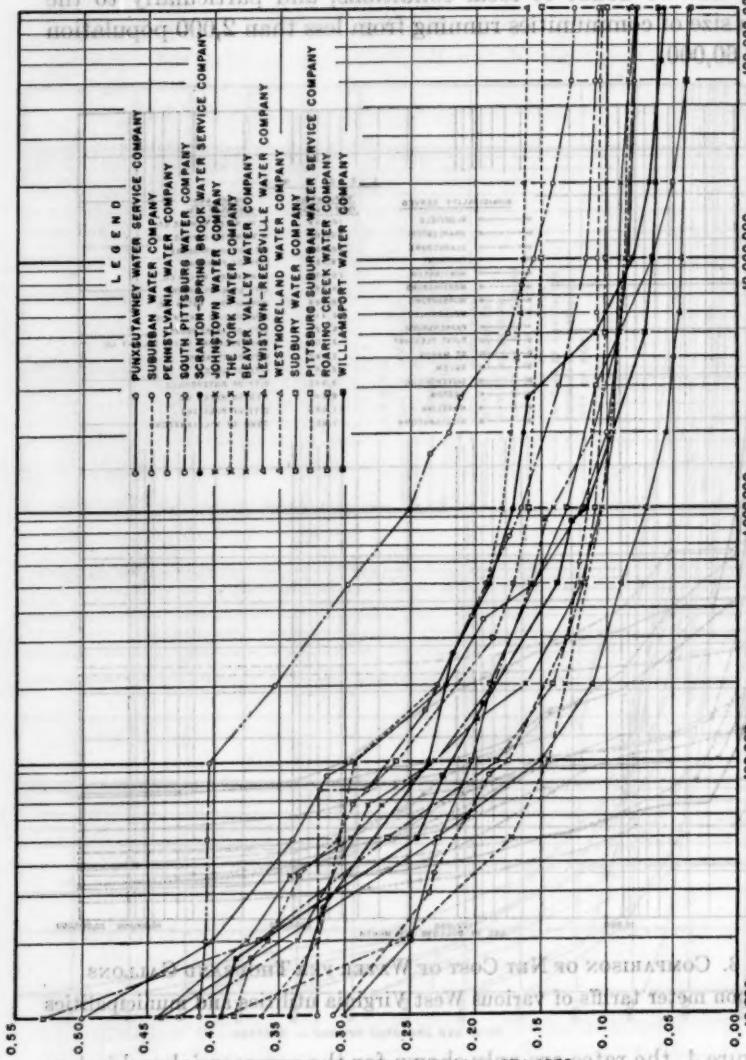

FIG. 4. COMPARISON OF NET COST OF WATER PER THOUSAND GALLONS
Based upon tariffs of various Pennsylvania utilities
Industrial rates only

is well to examine the diversified electric rates, because much of the refinement in calculating the two-part water rates was due to the development in rate analysis which the electric utilities were studying.

ELECTRIC TARIFFS IN GENERAL

A short description of general electric rates is all that it is possible to cover here, as time is not available to discuss the details of electric rate schedules. The diversity of electric schedules is best pictured by that of one company supplying numerous municipalities and having on file with the Public Service Commission over 200 different schedules. It is true that the difference in these 200 schedules is often minute and unimportant and the general trend in electric companies is to try to eliminate wherever possible alternate or optional schedules. To review briefly the form of electric tariffs, there are in general but three main types of energy charges:

(a) Straight line meter rates (constant price per unit)
(b) Step or saw tooth meter rates (Specified price per unit for entire consumption, depending upon particular step in which total consumption falls)
(c) Block meter rates (specified price per unit charged for all or any part of a block of such units with reduced prices for each succeeding block)

In addition, we have what are known as demand rates, of which there are three types:

(a) Flat demand rate (charge based upon customers' installation of energy-consuming devices)
(b) Wright demand rate (recognizes load factor conditions and charge included in an initial high rate per k. w. hr.)
(c) Hopkinson demand rate (charge based upon demand estimated or measured plus an energy charge based upon the quantity of energy used).

Today, practically all electric rates are a combination of the demand type with the energy feature. This is somewhat comparable to our water tariffs which have either a minimum charge or a readiness-to-serve charge combined with the output charges. There is one other type known as the "Three Part or Three Charge Rate." Such a rate consists of a customer charge plus both demand and energy charges.

MODIFICATION OF ELECTRIC TARIFFS

In the electric rate structure, there are many variable factors which determine the charge:

(1) Instantaneous power demand
(2) Fifteen-minute or one-half hour power demand
(3) Power factor
(4) Load factor
(5) Energy consumption
(6) Potential load
(7) Promptness of payment
(8) Character of service as to voltage, phase and frequency
(9) Location with respect to power company sources.

With so many independent variables, the problem of compounding a mathematical formula is one to whet the appetite of the calculus-minded engineer, and the temptation is often acceded to, so that each of these elements finds its way into the final tariff. In order to incorporate them in the schedule, we frequently find the tariff technical in its expression and often reading with the verbiage of the mathematics book or the court decision. This point is clearly evident in the following tariff of one of our large electric utilities:

Availability

Available for general purposes to any customer using the Company's standard service where the connected load is in excess of 5 kilovolt-amperes and where the required service capacity does not exceed 18,000 kilovolt-amperes.

Rate

Demand charge

First	5 kv-a. or less of billing demand	$14.00 per mo.
Next	5 kv-a. of billing demand at	2.50 per kv-a. per mo.
Next	20 kv-a. of billing demand at	2.00 per kv-a. per mo.
Next	70 kv-a. of billing demand at	1.50 per kv-a. per mo.
Next	200 kv-a. of billing demand at	1.00 per kv-a. per mo.
Next	700 kv-a. of billing demand at	0.50 per kv-a. per mo.
Excess		
over	1,000 kv-a. of billing demand at	0.25 per kv-a. per mo.

Energy charge

First 1,000 kwh. per month at 3.0 cents per kwh.
Next, a quantity of kwh. per month numerically equal to 40 times the kv-a. demand at 2.0 cents per kwh.
Next, a quantity of kwh. per month numerically equal to 40 times the kv-a. demand at 1.0 cent per kwh.
All excess energy at 0.5 cent per kwh.

Prompt payment discount

Upon payment of bill within ten days from date thereof a discount of 5 percent of the first $25.00 and 1 percent of the balance of the bill will be allowed.

Determination of demand

The billing demand shall be the sum of the individual demands of each metered service supplied, expressed in kilovolt-amperes, provided however that the billing demand shall not be less than 50 percent of the highest billing demand established during the six month period previous to the billing date.

The demand for each metered service where the connected load is 50 kv-a. or less may be estimated or measured as provided below. The demand for each metered service where the connected load is in excess of 50 kv-a. shall be measured as provided below.

The estimated demand for each metered service shall be based on the connected load and will be determined as follows:

First	5 kv-a.	of connected load at 100 percent
Next	10 kv-a.	of connected load at 85 percent
Excess over	15 kv-a.	of connected load at 70 percent

The measured demand for each alternating current metered service supplied shall be the average kilowatt capacity used during the 15 minute period of maximum consumption multiplied by the square root of the sum of one plus the square of the ratio between reactive kilovolt-ampere-hours and kilowatt-hours. This relation is expressed by the following formula:

$$\text{kilovolt-amperes} = \text{kilowatts} \times \sqrt{1 + \left(\frac{\text{reactive kilovolt-ampere-hours}}{\text{kilowatt-hours}}\right)^2}$$

Where demands are measured, instruments to record the reactive kilovolt-ampere-hours will be installed for various periods depending upon the size of the demands, as follows:

Tests for 14 day periods for demands below 100 kilovolt-amperes
Tests for 30 day periods for demands of 100 to 200 kilovolt-amperes
Continuous measurement for demands above 200 kilovolt-amperes

Demand meters and reactive meters will be installed at the option of the customer or the Company. Where the customer exercises the option a monthly charge of $1.50 will be made for the demand meter on each service where the connected load is 20 kv-a. or less and a monthly charge of $2.00 will be made for the reactive meter on each service where the demand is 200 kv-a. or less. Where meters are installed at the request of the customer and used for periods less than three months a removal charge of $1.00 per meter will be made in addition to the above. No charge will be made for demand meters where used on connected loads in excess of 20 kv-a. nor for reactive meters where demands are in excess of 200 kv-a.

If during any month the maximum instantaneous peak load, determined by test with a graphic recording meter, exceeds the average load over the fifteen (15) minute period of maximum consumption during that month by more than 35 percent, the demand will thereafter, or until some subsequent test, be increased 1 percent for each 10 percent, or fraction thereof, by which the

instantaneous demand exceeds 135 percent of the maximum fifteen (15) minute demand. The cost of such test is to be borne by the party requesting the test.

MULTIPLICITY OF TARIFFS

In the electric industry, there are separate rates for numerous types of customers. Separate and distinct schedules are set up for:

Individual and multiple residence service
Commercial service, lighting, power and baking
Small, large, general, seasonal, restricted high tension, off-peak and off-day power
Display, airway, municipal, carnival, hotel and sport field lighting
Cooking, water heating, and refrigeration
Cotton gins, textile mills, flour mills, and fertilizer plants
X-ray machines, floor sanders, fire alarms, poultry raising, air cooling, and pipe thawing

and many more.

The writer feels that the water works industry would have nothing to gain by accepting either the careful specifications or the multiplicity of the electric industry. The water works industry had just as diversified charges in the days of the flat rate schedule, but with the changeover to the meters, the simplification of a universal schedule has been of value in its simplicity of understanding and its lack of discrimination.

UNIQUE TARIFFS

The Federal Power Commission has recently issued pamphlets relating to its electric rate survey. In compiling these reports, it was found that schedules were so numerous and complex and involved such a variety of factors that it was impossible to apply them to given quantities of electricity on a uniform basis. The survey utilizes in place of the rate schedules, typical monthly bills for which more or less standard conditions as to use and quantity were prescribed. The Federal Power Commission says: "Simplification and Standardization of rate forms should be recognized as one of the most pressing challenges to the industry." The citation of a few examples of unique electric rates will show you to what extent this condition exists.

A schedule for billing a small domestic customer contains, for instance, this note:

"... provided that the gross amount of the bill shall never exceed a sum arrived at by adding to the bill, calculated at the net rate, an amount equal to (a) $1.00 plus (b) 3 percent of the amount by which the bill calculated at the net rate exceeds $10.00."

The average customer cannot figure the exact charge without considerable difficulty.

One company bases its schedule of rates on the number of cows which exist on a farm. Even the size of the farm is rated according to the number of cows. The schedule was uncovered by the Federal Power Commission's electric rate survey and is as follows:

SIZE OF FARM	FIRST STEP 10 CENTS PER KILOWATT-HOUR FOR THE FIRST—	SECOND STEP 7 CENTS PER KILOWATT-HOUR FOR THE NEXT—	THIRD STEP 4 CENTS PER KILOWATT-HOUR FOR THE NEXT—	FOURTH STEP 2 CENTS PER KILOWATT-HOUR FOR ALL OVER
	k. w. hrs. per mo.	*k. w. hrs. per mo.*	*k. w. hrs. per mo.*	*k. w. hrs. per mo.*
Up to 12 cows	30	40	70	140
13 to 20 cows	35	50	85	170
21 to 30 cows	40	60	100	200
31 to 40 cows	45	70	115	230
Over 40 cows	50	80	130	260

A cow is a cow, but the tariff added a clause designating the manner in which the number of cows shall be determined.

"The number of milch cows which the farm is capable of carrying, if operated as a dairy farm under normal conditions, with soil fertility in its present state, will be taken to determine the size of the farm. In case the consumer and the company fail to agree on the number of cows, each shall choose one man to represent him, and the decision of these two men shall be final."

Another company has a rate for "bachelor residential service" with a clause which only makes it "available for domestic lighting service in dwellings housing one lone occupant, serving not more than two outlets." Not to be outdone, however, another utility in the same section of the country furnishes "free service to widows," a majority of whom are not metered. When the bachelor meets the widow, there is still another schedule available to them.

One of the most intricate domestic schedules found by the Federal Power Commission provides that rates shall be adjusted on January 1 and July 1 of each year as follows:

"Net bills for service shall be increased or decreased at the rate of 3½% for each increase or decrease of 10 percent or major fraction thereof in the

algebraic sum of the weighted average of the following factors, expressed in percentage of such costs for the year ended June 30, 1934.

'1. The total annual tax bill in proportion to gross revenues from sales of service.

'2. The cost per ton of coal or fuel equivalent, delivered to the power plants from which energy hereunder is supplied.

'3. The average hourly rate of wage paid to utility personnel, excluding officers and directors of the utility.'"

In practically all of the major electric schedules in force in our municipalities, we find such items as fuel clauses, transformer discounts, phase unbalanced penalties, power factors, quantity discounts, prompt payment discounts, etc. To contend with all these, the business man, the factory manager and the plant operator are forced to depend upon the company's rate experts or upon the free lance rate experts.

Let us not be too hard upon the American utilities and at least give them credit for the fact that they have not reached the point of allocating the day of 24 hours into periods such as is done in Switzerland. In Lausanne, the 24-hour day is divided into four periods representing various degrees of load on the system, and the rate schedule is as follows:

High load period—rate, 64.5 centimes ($0.13) per k. w. hr.
Next load period—rate, 34.125 centimes (0.07) per k. w. hr.
Next load period—rate, 10.5 centimes (0.02) per k. w. hr.
Next load period—rate, 3.75 centimes (0.007) per k. w. hr.

In France, it is generally necessary to adjust the rates quarterly. As in Paris, for example, there is a base price per kilowatt hour, which is adjusted by three factors:

1. The price of coal
2. The salary of the consumer
3. Taxes

The rate is as follows:

Base price	0.50 francs	(1.8 cents)	per k. w. hr.
Coal price	0.42 francs	(1.5 cents)	per k. w. hr.
Salary factor	0.18 francs	(0.7 cent)	per k. w. hr.
Tax	0.22 francs	(0.8 cent)	per k. w. hr.
Total	1.32 francs	(4.8 cents)	per k. w. hr.

The above rate is further complicated by segregation according to usage and rebates are given. This rate is comparable to the one

previously quoted in this paper where the rates were adjusted January 1 and July 1 of each year, but it goes one step further, and takes into account the wage paid the consumer instead of the wage paid to utility personnel.

Although many of the elements of the electric schedule, such as load factor, on-peak and off-peak service, are strictly and mathematically just as applicable to the water industry as they are to the electric industry, the inadvisability of adopting such a schedule can best be demonstrated by redrafting a water tariff, bringing into it as many complexities as possible. Such a tariff might be designed for residential use and would read somewhat as follows:

RATES FOR WATER

Residence service

Availability

Class 1 customers using water for drinking and cooking purposes, together with a lawn sprinkler, using not less than 1,000 gallons of water per week in the summer, and Class 2 customers for the above equipment plus a bathtub with a control unit which permits not more than the use of 15 gallons of water per bath per week. If a shower is installed, the customer shall have the same controlled by an automatic valve to permit a mixture of not more than 5 gallons of hot water with 8 gallons of cold water per minute for not more than 10 minutes one day per week.

Rates

Customer charge $0.50 per month.

Demand charge

Varying with number of rooms and including a certain quantity of water in gallons.

Number of rooms	*Demand charge*
5 or less	$1.00
6	1.15
7	1.35
8	1.55
9	1.70
10	1.90

Output charges

$0.50 per 1,000 gallons, for the first 1,000 gallons, per gallon of demand.
0.40 per 1,000 gallons, for the next 2,000 gallons, per gallon of demand.
0.30 per 1,000 gallons, for the next 3,000 gallons, per gallon of demand.
0.10 per 1,000 gallons for all in excess.

Delayed payment charge

None—first 10 days.
2 percent between 10 and 15 days.
5 percent between 15 and 25 days.
10 percent after 25 days.

Determination of demand

All connected rooms in the residences are counted (whether plumbing fixtures are installed or not) except halls, pantries, corridors, porches, and alcoves, unfinished attics, bath rooms, lavatories, furnace rooms and basement laundries, also garages with a capacity not exceeding two cars, garages in excess of 2-car capacity and outbuildings counted as one room for each 5,000 cubic feet (or fraction) in the first floor. Such floor to be considered not over 15 feet high; also servants' rooms therein counted. Each bath tub and laundry tub, not including any tub of less than 50 gallons capacity, nor any portable washing machine, with a capacity under 25 gallons of water considered as two rooms. Minimum, 3 rooms.

Rider. All charges shall be based upon a constant delivery of not more than 5,000 gallons of water per month per customer, with customer charge applying to not more than 3 rooms, and an additional customer charge of 10 cents per room for each additional room not including hallways, alcoves, closets, pantries, bath rooms, attics, etc. A special discount of 10 percent is open to all customers who have installed storage tanks of sufficient capacity to store enough water for bath room use and drinking water purposes, during the heavy demand period, and who shall fill such storage tanks in the off peak period from 12:00 midnight to 4:00 A.M., but such discount shall not apply unless the bill is paid prior to the 10th of each month.

Of course, you may say that such a schedule is ridiculous and if we were to submit such a rate schedule to a consumer, he would probably tell us to shut off the water. A well digger would be immediately hired to dig a well and the consumer's only problem would be to buy a pump from a good manufacturer. Unfortunately, however, wells do not always produce.

PROMOTIONAL ELECTRIC RATES

The electric industries are instituting so-called "Promotional Rates." Not satisfied with the variety of existing tariffs, and to offset declined business and encourage additional use, rate tariffs are introduced which are often a variation of the minimum charges for existing rate schedules. Some companies give free electricity if you use an amount over and above what was used the same month last year.

The first promotional rate in the electric industry was instituted by

the Pacific Gas and Electric Company, which offered free electricity. It was soon followed by the Milwaukee Electric Railway and Light Company. The first offers were only temporary bargains and trial offers. The Commonwealth and Southern Corporation was the first company to institute a constructive permanent bargain offer and it covered the Tennessee Valley properties. This was followed by the Pacific Gas and Electric Company's revised offer. The Hartford Company followed suit and then the Public Service Commission of Wisconsin announced a so-called "low cost plan" for that State. The movement seems to be spreading rapidly throughout the electric industry, but the plans have not been in effect for a sufficient length of time to warrant any conclusions.

There is only one water works to our knowledge that has a rate nearing the promotional type. This rate, however, is not strictly a promotional rate in the sense the electric companies are using the term, but really an "off peak" rate. The utility offers a lower rate for water if it is taken during certain hours at night, and it is termed an "off peak rate." This utility pumps all of its water and of course the pumping personnel at the stations is needed during the night, the same as during the day, and therefore the only additional cost to keep pumps operating at capacity during the night is the cost of electric power to operate the motors. A reduced rate is therefore granted. Of course, only large manufacturing plants or railroads having storage capacity could obtain this rate.

WATER RATES

All water rates do not fall outside of the complicated realm. However, complicated rates are in a minority. The average man who knows how to use grade school arithmetic can determine what the cost of his water will be readily from the great majority of existing tariffs, knowing of course the number of gallons or cubic feet of water used and the size of the meter. However, there are a few odd water tariffs. In a Southern city, the minimum rate is based on the estimated value of the residence or place of business. No doubt, this brings the City Assessor into the picture, because the water rates depend upon the value determined for your property. If your property has a value over $600, the minimum rate is $12.00 per year. Under a $600 value, the minimum is $8.00 per year, and under $400 a minimum of $6.00 per year is established. Each minimum includes a certain allowance of water that may be used per year. If more than

the stated allowance is consumed, the excess is charged for by a block rate schedule. A number of meter tariffs exist which consist of many blocks, some having as high as 11, 15 and 19 blocks. Schedules having many blocks can be revised and simplified.

Another out of the ordinary charge is in a city which has a rate for private hydrants of $5.00 per quarter, and the owner is entitled to $0.25 rebate on fire line bills for every dollar paid on domestic water bills.

CONCLUSION

In general, the meter rates in water tariffs consist of a minimum charge or readiness-to-serve charge combined with step block output charges and are therefore not of a very complicated nature. The public feels more kindly toward us for keeping schedules understandable. In doing so, we have done something worth while for them and for ourselves and at the same time we have established in the minds of the consumers the spirit of trustworthiness.

They say "to be forewarned is forearmed." I hope this paper relating to involved, complicated rates will serve its purpose and act as a danger sign to warn operating men serving the general public with water not to follow the example of our neighbors. Let us, therefore, continue in the future, as we have in the past, keeping our rate schedules as simple as possible, avoiding the development of rates for different classes of service, and above all, avoid incurring bad relationship with consumers by the institution of any scheme that makes them feel a distrust toward us.

The writer acknowledges the assistance he has received from Mr. John W. Guilday in the preparation of this paper.

(*Presented before the Central States Section meeting, August 23, 1935.*)

MODERN METHODS OF CONTROLLING ELECTRICALLY OPERATED PUMPING STATIONS

By S. A. Canaris

(Bureau of Water, Pittsburgh, Pa.)

If I were to talk about modern methods of controlling electric power stations or substations, my task would be a comparatively easy one, due to the fact that it is possible and practical to standardize the layouts and design for most of such stations; the operating conditions are definitely known, and means are available for making exact estimates of voltage, short circuit currents, regulation, etc., for any point or part of the system.

In contrast to this, we seldom find two locations where we can use identical pumping and control equipment. Local factors must be carefully considered in close coöperation between the hydraulic, mechanical and electrical engineers, and where these engineers fail to have a working knowledge of the other man's problems, the results are usually jumbled layouts and unsatisfactory operation.

It would, therefore, be folly to attempt to cover the entire field, or to presume that this short paper may do more than touch on generalities. However, I hope that it may convey to the water works engineers some idea as to the practical possibilities of modern control applications.

Electrically operated stations may be classed under two main groups, as (1) Attended, and (2) Un-attended stations. From a purely technical standpoint the first group may eventually be eliminated, except in a few cases where the cost of operators is justified by high fixed charges, or by excessively complicated automatic equipment with pertaining high inspection or maintenance cost.

Un-attended stations may again be classed as automatic or remote controlled, with possible combinations of the two types. Automatic stations are those in which the equipment is started and stopped through relays which are controlled by reservoir levels or system pressures, or by faults in, or failure of, station equipment or connections.

Remote controlled stations are those in which all or the major part of equipment is controlled by operators in a remote location, either through a direct wire control or through a so-called supervisory control system.

A common misunderstanding is that the protection of equipment in an attended station differs from that in an un-attended station. Any equipment deserving protection should be fully protected against all faults which might result in damage, and which can not be detected by the operator before its occurrence. One of the few exceptions may be the use of bearing thermal relays, but even there the comparatively low cost of such equipment well justifies their use in all cases. Another exception is that of protection against loss of suction pressure, which we in this City are using only in un-attended pumping stations.

In the design of new stations we are providing the following protection:

1. Induction type relays, protecting against short circuits, and against overloads caused by excessive pump load, "frozen" pumps, etc.
2. Ground relay, to disconnect grounded equipment before the fault develops into short circuit. Used only where "wye"-connected current supply with grounded neutral is available.
3. Low voltage relay, to protect against voltage failure.
4. Phase balance relay, to protect against unbalanced operation or phase-failure, on synchronous motors only. Small induction motors are considered adequately protected against injurious single phase operation by the induction overload relays, set at about 125 percent of full load.
5. Field failure relay, to protect against open motor field or exciter failure.
6. Timing relay, to protect against more than 2 or 3 consequent unsuccessful attempts to complete starting cycle, or against continued operation of synchronous motor as induction motor as in case of continued electric system disturbances preventing synchronous operation.
7. Relay to remove the direct current field in synchronous motor, when the motor drops out of step, and to again apply it when "near-synchronous" speed has been attained.
8. Bearing thermal relays on all motor and pump bearings, usually adjusted for 160°F. for anti-friction bearings and 190°F. for sleeve-type bearings.

9. Limit switches on the automatic cone-type check valves on pump discharge, so arranged that they will trip the motor in case of faulty valve operation, that is, when the valve closes due to a failure in its electrical or hydraulic control.
10. Lockout relay, which is operated by such faults as will require mechanical or electrical repairs to the equipment before restarting. These faults are: Overload, short circuit, ground, hot bearings, field failure, and failure of discharge valve control. When this relay has operated, the unit cannot be started again until the relay has been reset by hand.

All relays, including lockout and bearing thermal relays, are provided with operation indicators in form of annunciators, which drop a target after an operation, so that the inspector can locate the faulty part at once.

In connection with protection of equipment the water valves play an important part. All new stations are now being provided with hydraulically operated valves of the rotary type, on each pump discharge line. The operation of these valves is controlled by an electrically operated solenoid, which is energized and thereby opens the valve, when the pump attains a near full load or synchronous speed, and de-energized, and thereby closes the valve, when the pump motor is stopped.

In attended stations, where we have large units, such as Brilliant Station with 24-inch pump discharge, we have a 30-inch motor operated gate valve between each cone valve and the line, so that the pump can be stopped, at reverse speed, in about 2½ minutes, if the cone valve fails to function. For small, unattended booster stations where the dynamic head is comparatively small, and where the cost of possible, if not probable, damage to a pump on account of reversal does not justify the additional means of automatic shut-off, we install a hand operated gate valve between the cone valve and line, for maintenance purposes only. In the case of a high-head pumping installation, such as our Saline Station, where the discharge head is about 230 pounds, we have installed one hydraulically controlled rotary type cone valve in series with the electrically controlled cone valve. This was considered necessary, as the possibility of power outage would have made an electrically operated gate ineffective.

We have found these hydraulically operated rotary cone valves very efficient and reliable, and fairly easy to adjust for proper timing of opening and closing strokes. The proper timing is, of course, essential for protection against surges and water hammer which might

damage the pump or piping system. Where the operating pressure is high or very variable, a special water power supply is essential for the proper valve operation.

At the Saline Station we have installed such a supply system, fed through an 85 pounds reducing valve from the 230 pounds discharge line to a water accumulator, and from there to the valve hydraulic operating mechanism. An emergency supply is available from the 65 pounds suction main. A small air compressor maintains an air cushion in the accumulator tank, so proportioned that a simultaneous operation of four valves will drop the tank pressure from 85 to 80 pounds, in case the supply is lost due to a break in the discharge line. The valves operate satisfactorily even at the 65 pounds suction pressure, although the operation is about 25 percent slower than that desired for ideal operation. The advantage of this stable and comparatively low pressure water power supply is primarily the coarser setting of the water control parts in the valves, so that a slight change in these openings will have only a small effect on the operating speed.

It has been necessary to mention the different forms of protection because they are so definitely inherent parts of the entire set-up of any successful and modern control schemes.

PITTSBURGH PRACTICE

We have, here in Pittsburgh, four modern, electrically operated pumping stations which may well serve as illustrations of clean-cut forms of control. Most of these stations may be visited during this convention, so that it is not necessary to describe the details in this paper, but only to mention such features of control which deserve special mention.

Brilliant Pumping Station, with a total installed capacity of about 180 mgd. in pumps, with 12,000 h.p. in motors, is an attended station, entirely controlled from a centrally located control desk. A complete description may be found in the October 18, 1933 issue of "Water Works Engineering." The control is of the conventional type, starting the motors through reactors to reduce the starting voltage, and automatically applying the full voltage and the field at proper time. No provision has been made in this station for re-synchronizing the motors after they have fallen out of step due to a line surge or similar electrical disturbance. This provision was not possible, as the pull-in torques of the 2250 and 1500 h.p. motors are only 60 and 50 percent respectively of the full load torques. However, it is not an essential

feature in an attended station where all water is pumped directly to large storage reservoirs.

The simplest form of un-attended automatic stations is the continuous duty station, usually installed as a booster station, with two identical pumping units, of which only one is in operation at a time. The control for such a station is extremely simple, consisting of standard motor starters and protection, and of a selector switch which selects either one of the two units for normal operation. If a fault occurs in this selected unit, it will operate its lock-out relay, thereby automatically stopping the faulty unit and immediately starting the other unit. The faulty unit, having been taken out of service through the lockout relay can, of course, not be started again until this relay has been re-set by hand. A good example of this type of control is found in our new Highland Pumping Station; and incidentally, this same station is a very good example of how application of architectural design can make a pumping station a distinct attraction in a residential district.

A variation of this type of station is the station that pumps to a reservoir, whether directly or through a distribution system. The control equipment is similar, but additional provision must be added to start and stop the pumps as required, either based on the reservoir level or system pressure, or a combination of both. Where a direct rising main to the tank or reservoir is available, the static pressure corresponding to low tank level, and the dynamic pressure corresponding to high tank level can be definitely determined, and a suitable pressure relay in the station can control the pumps. Such a relay, usually provided with diaphragm operated mercury type switches, can recognize a differential of less than ½ foot of water, and provides a reliable and definite control of the pumping units. Any form of relay which controls equipment as a function of pressure must be combined with some form of surge protection, to prevent unnecessary operation of motor control equipment. A simple and reliable form of such protection may consist of a thermal relay, in which the heater element is controlled by the pressure relay, and the bi-metal arm actuates a contact or switch, directly connected in the motor control circuit.

Where a direct rising main to the tank is not available, and water is pumped into the distribution system overflowing into a tank, the same form of control can be used in connection with a static pressure connection from the tank. In the case of our Lincoln Pumping Station

which was re-equipped for automatic operation this year, such a pressure connection was not available, and the pressure relay for shutting off the pump motor when the tank is full, was located in a manhole near the tank. The electrical connection from this relay to the pumping station is a rented telephone circuit of approximately 930 ohms resistance. The closing of the pressure relay at full tank operates a clapper type telephone relay at the station, thereby closing a local circuit to the thermal "surge" relay which in turn opens the motor control circuit after a delay of about 2 minutes.

In case of a fire, filling of a swimming pool, or other unusually heavy water demands, the distribution pressure drops below the normal pressure corresponding to low tank level and normal water demand. In such case the pressure relay with its thermal "surge" relay will start a pump if such condition of heavy demand is continued for more than about 2–3 minutes, and the distribution system pressure will be restored to near dynamic pressure, while at the same time we preserve the built-up storage in the tank.

Many combinations of this type of control are possible, and while the type of equipment is similar, the location of it must be carefully chosen to prevent false indications and operations.

The older type of tank control, by use of float switches, has always been a source of trouble, mainly due to ice and to tampering with the equipment.

The success of automatic stations is mainly due to the standard commercial protective equipment of to-day, which in most cases is more reliable, and which recognizes changed conditions much quicker and more accurately than even the best trained operator.

It would probably be feasible to operate all stations automatically, but the complications of a water system would often necessitate automatic control equipment of such an intricate nature that the cost would become prohibitive, and maintenance extremely difficult. We also find cases where the operation of one or more pumping stations must be coördinated for proper system operation, and information be exchanged between the stations. In some cases it would be desirable to show the operation of equipment in the un-attended station, on indicators located in another pumping station where operators are maintained.

Any of the above cases may usually be most satisfactorily solved by the use of a complete remote control system, which not only gives an indication of the operation of the un-attended station equipment and

conditions, but also completely controls such equipment from a remotely located, attended station or system operator's office.

Equipment for this type of control has been developed, during the past ten years, primarily for the use in power company systems, for the remote control of generator stations, substations, etc., and has now reached a stage of perfection and reliability that makes it possible to use it for any form of operation or indication necessary for the successful operation of pumping stations. It has been thoroughly tested by its use in practically all of this country's electric utility companies, and through its widespread use it has reached a stage of production where the cost makes it universally available.

REMOTE CONTROL METHODS

Several systems have been developed for remote control, in general classified as (1) direct wire remote control, and (2) supervisory control.

Direct wire remote control is, in general, only practical for the control over a short distance where a reliable installation of a multiconductor control cable can be maintained at a cost comparable to the simpler supervisory control circuit. It requires that all control circuits be extended from the operating switchboard, through interposed low energy relays, to the control point, and also extentions of circuits, with transmitting and receiving equipment, for remote metering, if desired. The installation of such a system is simple, but its application is somewhat limited by distance.

Supervisory control systems are such systems which operate and indicate over a few wires, usually one 2-wire telephone circuit. Two distinct types are commercially available, the audible type, and the visible type.

The audible type of supervisory control employs a dispatcher's equipment similar to the conventional dial telephone, from which the remote controlled equipment is selected and operated by sending out of coded signals consisting of a certain number or combination of impulses. These impulses are then received by the supervisory relays at the receiving station, and each coded signal sets up combinations of these relays corresponding to the desired selection or function of equipment, and thereby operating the equipment through interposing relays which are part of the receiving equipment. Return signals after selection and operation, as well as signals by checking, comes to the dispatcher as buzzer signals corresponding to the selection or

operation signals, and an alarm is automatically sounded in the dispatcher's station in case of an automatic operation in the station which changes the position of the operating equipment. This alarm is essential for successful use of an audible system.

The visible type of supervisory control is quite similar in its function. In this system, however, the dispatcher's equipment is usually in the form of miniature control desk equipment, with control switches, indicating lamps, and meters. The same form of impulses are transmitted to the receiving station, but the twisting of a control switch or pushing of a control button automatically sets up the proper combination of signals, and the operator will always have a complete picture in front of him of the position of all equipment and conditions in the operated station. Remote metering of voltage, pressures, etc. can be shown directly on indicating meters on the dispatcher's panel.

The choice between these two systems depends entirely on the local conditions. The audible system has the advantage of low first cost, although visible systems are now available for operation of a small limited number of equipment units at a comparable cost. The visible system has the distinct advantage of the continuous visual indication, and is not apt to cause confusion in operation and interpretation of signals as in the case of the audible system, where the operator must keep his own record of previous operations to know which units are operating. The visible system is, furthermore, much faster in operation than the audible system.

Our new Saline Pumping Station is an example of a supervisory controlled station. This station is intended for continuous operation, pumping into the high areas of a district which was previously supplied from the Herron Hill Pumping Station. Due to inadequate distribution system, satisfactory pressures could not be maintained in the high areas, even though a special high-pressure electrically driven pump was operated at Herron Hill Station. Ample pressures are now obtained by pumping from Saline Station into these high areas, which are segregated from the rest of the district; excess water is relieved through a pressure controlled, balanced valve, to the Herron Hill System and its storage reservoir. In case of a long time power outage at Saline Station, it is essential that the Herron Hill high pressure unit be put in operation at once, to maintain the best possible pressures in the high areas. The entire Saline Station is controlled from Herron Hill Station, about two miles away, over visual supervisory control. Two circuits are rented from the Bell Telephone Company;

one of these is normally used for control and the other for communication, and provision has been made for automatic line fault indication and semi-automatic transfer of functions from the defective to the sound line.

It is of interest to note that the entire cost of the supervisory control installation for this station, including the dispatcher's equipment located at Herron Hill Station, was considerably less than one year's cost of maintaining operators at Saline Station.

In connection with modern control methods it is necessary to mention the necessity of regular inspection and maintenance of the stations and equipment. The inspectors must be intelligent, observant and reliable, and must be specially instructed and trained to analyze and correct faults and fault indications. Operations and faults can be completely tabulated, so that even in-experienced operators may operate remote stations successfully over the Supervisory Control.

With the ever increasing use of electrically operated pumping stations, we are undoubtedly going to see the establishing of central control points or dispatcher's offices from where all of a city's or district's electrically operated pumping stations are controlled by remote control.

The developments of equipment for automatic and remote controlled pumping stations has opened many possibilities for the electrification of stations, with elimination of the many uncertain factors in labor conditions, coal supply, deterioration of steam equipment, etc.; many water works engineers have already taken advantage of these developments and thereby obtained substantial reduction in operating costs and increased reliability in operation of their departments.

DISCUSSION

D. E. Davis (*of Chester, Leboon, Campbell, Davis and Bankson, Consulting Engineers, Pittsburgh, Pa.*): We are accustomed to hail ours as a new power age, unique because of the application of electricity, which affords a flexibility unattainable in older forms of power, admitting of infinite divisibility, wide geographical distribution, and (more particularly) of accurate and dependable means of control. Mr. Canariis in this thoughtful paper has well illustrated the application of modern control methods to the problems of electrical pumping.

Most operators will heartily endorse his thought that however complicated the internal protecting mechanism may be, the final

control as visualized by the operator, should be as simple as possible to avoid confusion. The use of annunciators or "tell-tales" on relays will help the operator to locate the cause of outages with a minimum of search and delay, and are certainly worth their cost.

Often, as the author notes, it is necessary to control pumps by mechanism governed by the changes in the water elevation at tanks or reservoirs. For most situations the diaphragm operated mercury switch is admirable, but, for fine gradations of control or the transmission of water elevations, the mercury column actuated type offers advantages. Two wire controls employing rental telephone pairs are increasingly popular as it makes possible the elimination of maintenance and electrical troubles often encountered on long, separate control lines.

The author's observations are largely confined to pumping stations, as separate independent units, but in many communities, pumping is an integral part of a plant operation often including filtration or softening as the major function. Such plants will usually be "attended," and the designer's problem is that of keeping labor requirements at a minimum and simplifying operating features. An example of this type of plant is the new West Side filtration and pumping station at Erie, Pennsylvania, in which still another type of control was employed, illustrating the author's statement that each situation presents problems peculiar to itself.

The low service pumps at the lake shore are remotely controlled by direct wire service from the high service station and filtration plant located on the bluff about a quarter mile from the lake.

The entire electrical pump control for both stations is grouped on a desk about the size of an ordinary office desk top. In starting the plant, the operator presses a button for a low service pump which immediately lights a pilot lamp along side, indicating that power is available. A vacuum pump starts automatically pulling water up into the low service casing while the development of this vacuum is transmitted to an indicator on the back of the control desk in front of the operator's eyes. When the pump is primed the vacuum pump is automatically stopped and the low service pump started. The fact of water delivery is shown on a Venturi meter nearby, and the electrical current inrushes incident to the operation are visualized on the board ammeter, while at the same time a set of ear phones connected to a microphone at the lower station provides audible confirmation of the activities at that plant. Should the pump fail to deliver water or should the bearings overheat the pump is automatically shut down.

The control desk provides means of starting and stopping the high service pumps, and of actuating the motor operated circuit breakers which control the electrical supply to the plant, whose operation in turn actuates the outdoor switches at the Power Company's substation. Minor motors about the station may be stopped from the control desk but must be started by the operators. Solenoid operated cone valves protect all pumps against water hammer. A "balancing pump" at the low service station cuts in automatically by float control from the sedimentation basins in order to iron out minor fluctuations in demand.

A rather special problem advantageously met by electrical control is illustrated at another Erie station. A part of the system about seven miles east of Erie's open storage reservoirs, experienced a severe reduction in pressure in the early evening hours of a summer when the sprinkling load was excessively high. A simple double pole mercury diaphragm actuated starter admitted of placing the pump on the line at a speed of about 1500 rpm when the pressure dropped to a certain predetermined point. Should it drop further it automatically cut in at its rated speed of 1750 rpm thus increasing the delivery and pressure. As the sprinkling load diminished the pump returned to the lower speed and finally closed down automatically. The arrangement successfully met the problem of maintaining adequate pressures at all times and at low cost.

The flexibility afforded by electrical control is illustrated by a recent application to deep well pumps. Three pumps of 500, 800, and 1200 g.p.m. capacity respectively, deliver into a system where the fluctuations in demand are reflected in a comparatively small balancing tank. A float actuates a cam operated controller which transmits its impulses to a control board by direct wire circuits.

Seven combinations of pumping rates from 500 to 2500 g.p.m. are made possible in such manner that the frequent starting and stopping of pumps is reduced to a minimum. When one combination is operating the other pumps are held out until a stop point is reached, when another combination may then be chosen. Should the demand exceed the pumping rate, the water is made to drop through the greater part of the tank depth until its stop is encountered, which at the same time starts the next higher combination. A time delay maintains a slight overlap so that the pump being started has an opportunity to deliver water before the lower capacity pump, which it displaces, is shut down. The second combination pumps the tank up through the range until it encounters its upper stop at which point

the next lower combination starts. The control is largely through simple relays which operate the pump starters.

Photo-electric cells, relays, supervisory control systems and other new electrical tools are making it increasingly possible to control a wide range of operations in a wholly automatic fashion. It requires no great stretch of the imagination to foresee the principal functions of many, if not most pumping stations, performed by these dependable and accurate contributions of the electrical engineer and inventor.

(*Presented before the Central States Section meeting, August 22, 1935.*)

MATERIALS FOR SERVICE CONNECTIONS

By Frank M. Murphy

(Water Department, El Paso, Texas)

In selecting material to be used in any class of construction one should be guided by so many factors and conditions that no iron clad rule can be used. Standardization in the use of water works material is the ideal, but just try to adopt a standard that will please anyone except the manufacturer and dealer in the favored article. The purchasing agents claim it cramps their buying power, the material man, whose product is not specified, puts the fire under you through his local agent who, he makes sure, is an influential taxpayer.

If you are fortunate enough to be free from political domination in choosing material, you may weather the storm. Otherwise, you may find yourself using a substitute for what you know to be better practice.

In discussing the materials used for service connections, it is not my intention to criticise anyone's product, and my only wish is that my remarks may be accepted as constructive.

A service line is the lateral from the main in the street, or alley, to, or into, the property to be served. This service can be of any size from the minimum used to the size of the main itself and still be classed as a service.

There are so many different views as to the ownership of services and who should stand the maintenance and replacement that what is a practice in one water system may be just the opposite in some other.

In choosing the material to be used, quality and past performance, rather than unit cost, should be your guide. Many times material is bought with the only thought in mind that it is cheap, enabling some purchasing agent to point to the savings he made by accepting the lowest bid, when in reality, the material in question will give only half the service of one a few cents, or dollars, higher. This is particularly true in brass goods and meters—two of the essential parts of a service.

Don't be fooled into thinking that the meters, or brass goods, that

you can buy at half the price, are equal to the standard makes, the only comparison being that they look something alike from the outside.

This apparent saving is one of the hardest obstacles you have to overcome. In the brass goods, or pipe, your loss, when it comes, means only replacement and labor, but in the meter you sap the very life blood of the department as well.

One of the points that should not be overlooked is that the bonds that pay for most water works improvement mature in forty years. Do not plan to renew a service several times before the original bill is paid.

EFFECT OF SOIL

In West Texas you find many kinds of soil. Some of them very destructive to certain metals in pipe lines.

The Western Gas Company has a pipe line that starts 200 miles East of El Paso, furnishing El Paso with natural gas for all uses. This pipe line continues across New Mexico to Douglas, Arizona, and then on to Tucson and Phoenix. A study is being carried on by this company in an effort to protect its lines from electrolytic action. Their engineers are more than pleased with the results of their efforts, as they have been able to keep their lines negative through El Paso at very little cost per mile. Mr. R. H. Cowan, in charge of this survey and study, informed me that their next move would be on the cross country lines by using wind mills to run their generators.

Within the City of El Paso there are three kinds of top soil structure. About one-fourth is caliche. This is a conglomeration of gravel and stone bound together with almost pure lime. Some of it is fairly soft and can be trenched with pick and shovel, while, in other cases, it takes a paving breaker, or better, a few shots of powder, in order to make the necessary excavation.

Pipe lines in this caliche are practically immune from wear. Black steel lines laid twenty years are still like new on the outside. Some element in this soil forms a glaze on the surface of the pipe which protects it.

One-fourth of the city has what we call swelling clay. It is between a brown and red in color and is very hard when dry. This material expands with moisture and contracts as it dries, the amount of expansion depending, of course, upon the degrees of moisture. A street, or structure, laid upon this clay will be damaged if water gets under it.

Pipe lines laid in this material are subject to a severe test, and unless protected, are destroyed in very short time. Steel and cast iron have a life from 5 to 10 years.

The other half of the city is in average soil, or sand, with the life of steel and wrought iron pipe from 10 to 20 years and cast iron not affected.

What is good in one place may not be desirable a short distance away. You have the choice of materials that will meet any specification: steel, wrought iron, lead, copper tubing, brass, cast iron and asbestos. Before making any comment on these different materials, many of you will disagree with me. That is to be expected, as climatic conditions make different types of construction necessary. The overcoat we use in winter in El Paso would not keep you warm in the North and East, and a raincoat is a curiosity in West Texas with 3 to 10 inches of rainfall per year.

CONDUIT FOR SERVICE

The water works of this country could learn a great deal from the telephone and telegraph people. They would not think of running a line in the ground without first putting in a conduit, and they seldom have trouble with their cables.

A service line should be protected in the same manner, and should it be so constructed, its life would be doubled, or trebled. Why do we sell our old pipe, 1½ to 4 inches to the junk man for a song when it would make a conduit for house services that would pay real dividends.

STEEL AND WROUGHT PIPE

The trend is away from these materials for service lines, but it would be a good guess that the manufacturers of these products, sure of their influence, will increase their efforts for this business. You will find many cities continuing with, or going back to, this type of service materials.

CAST IRON PIPE

In the last ten years, several manufacturers have entered the market with cast iron pipe in the smaller sizes, 1¼ to 3 inches. Until that time, this part of the distribution system depended upon steel, or wrought pipe, unless the installation of lead could be afforded, or the installation of brass, which would increase your service cost to a point where it would be all but impossible to sell the idea to a board

their stems. A properly designed wedge that releases the gates puts practically no strain on the stem. Of course, if the wedges fail to operate, and the gate is straddled over a track, or guide, it is no wonder that stems fail. Go back over your own valve failures and see if most of them were not caused by one, or both, of these points.

On house service lines, ¾- and 1-inch, we use a compression stop. This is of special design which gives full water way. You who have never used anything except ground kep stops may think this a queer idea. In defending this stop, let me say that it is the most popular thing we ever did. The consumer took to it like wildfire, and our hardest fight now is satisfying those who still have the old stop cocks. This valve can be operated as easily as the faucet in your yard. Calls on the depargment to shut off water are few and far between. You will probably say that the consumer has no right shutting off the water, or that he should furnish his own cut off. I shall not argue that point. We tried both ways and find that the average home owner likes a valve that he can operate by hand, as the tools in the average home are very inadequate, and when a pipe breaks in the night it makes him feel good to think that he can shut his own water off.

In the final analysis, it is this customer who pays the freight. Let's make a booster out of him.

METER BOX

Here is another item that we do not all agree upon. There are cities that would not think of putting in a meter box without a lock on it. I, for one, do not believe that the meter should be locked in a box, except in exceptional cases. The general public does not have much faith in the reliability of a meter, and the very fact that the public is locked out of it does not help this belief. The public will tell you that the gas and electric meters are open for their inspection and the reading may be checked if so desired,—so why should the water meter be locked up if there is nothing to hide? Of course, we seal the register and sometimes the inlet coupling to insure against tampering with the meter.

METER YOKES AND MANIFOLDS

Where a copper service comes straight into a meter, we have found that it is necessary to use a yoke, because where it is not used, the copper will pull until there is not room for a meter setting. In most

of our settings, the pipe from the street enters the meter box from the bottom, giving us a swing pipe to fasten the meter onto.

For battery settings which we use entirely on larger services, a manifold is made of brass fittings. Each meter is double valved, allowing us to make individual repairs without disturbing the service.

METERS

With break-down tests conducted over a period of years, we have proven to our own satisfaction that we get in a meter only what we pay for. Do not buy competition meters. Most of these cheap measuring devices are put in by the contractor on the original installation, his only interest in the welfare of the project being a bid low enough to get the contract, or by some board of councilmen who do not know the difference. You can be sure of only one thing when using them: the water department always takes the loss.

In the larger size service, a battery of 2-inch meters gives the best service. We arrive at this conclusion by running them in tandem with large meters, and have yet to find a condition where the battery will *not* increase your revenue.

On fire line services, the installation of a detector check will show you that these services are not as inactive as you might think. The detector meter pays dividends in leaks and stolen water.

(Presented before the Southwestern Section meeting, October 14, 1935.)

PLANNING ADDITIONS TO THE DISTRIBUTION SYSTEM

By F. M. Veatch

(*Consulting Engineer, Kansas City, Kans.*)

The extension of the water distribution system is one of the very important routine matters in every water department because water must be supplied to new consumers and city growth creates new fire demands which must be met. Piecemeal extension is a fairly simple procedure for a short time and insofar as individual consumers are concerned, but when continued for any length of time it leads, as every superintendent knows, to serious complications within the system as a whole. The distribution system represents from 40 to 70 percent of the total capital investment in water works and its position in the water works picture is so important that the advisability of rational planning for its expansion to meet growing demands cannot be questioned.

The problem is essentially individual, as cities are built and extended in many different patterns to fit local topography and existing facilities for transportation and industry. Any analysis of the subject must necessarily be quite general. Helpful advice, except in individual cases, must be limited to a statement of the problem and an outline of solution methods.

The criterion of successful water distribution is the ability to serve consumers and to meet fire demands in all parts of the system and therefore rational design of additions must be based on accurate knowledge of existing conditions of pressure and demand throughout the system coupled with reasonable estimates of future demands. This calls for the determination of the domestic and industrial water consumption and fire demand in the various parts of the system and the correlation of this data with existing and probable future city development. If it is known definitely how much water is required at a given pressure at any point in the system, it is a relatively simple matter to calculate the size of mains, the amount of elevated storage and the pump capacity necessary to meet the demand. The economic side of the extension problem is not quite so simple, but in any event these data are essential to any rational solution of distribution

problems and should be gathered during routine operation if possible, rather than in a limited time immediately prior to the start of some important project.

The data commonly needed for planning distribution system additions is roughly as follows:

1. A number of base maps, drawn to a convenient scale and showing the distribution system with its pumping stations, elevated storage structures, valves, hydrants and mains indicated thereon by some convenient system of notation.
2. An accurate topographical map drawn on one of the base maps to show the elevation of the property served and of the various parts of the distribution system.
3. A spot map made by plotting the buildings of various types on the base map, to show the character of development in various parts of the city. "Sanborn" maps or Zoning plans are of assistance in this work but usually a field canvass is required. Such a map is of great benefit when it is necessary to divide the city into districts classified by water usage or demand and offers a convenient means of showing proposed or probable development in outlying sections.
4. One or more pressure contour maps formed by plotting observed pressures in various parts of the city under various operating conditions. Such a map will usually indicate the weak points in the system, and is quite valuable for purposes other than of main extensions.
5. Consumption Studies. Naturally a more or less complete record of total water consumption is kept by the majority of water departments, but a surprisingly small number of them go more deeply into the matter by attempting to divide the total pumpage into its various use classifications which include domestic and commercial, unaccounted for water, etc. However, if additions to the system are really to be rationally designed, it is necessary to go farther than this and analyze the consumption in each of a number of sections of the system. After the normal consumption is determined by actual measurement by pitometer or otherwise or estimated from an analysis of meter records, the fire demand in each section of the city as required by the underwriters must be determined from the district population and class of development as shown on the spot map mentioned above. The results of this

study may conveniently be shown on a map which shows the distribution system and quite often it is possible to locate weak points in the system by inspection, particularly when comparison is made with pressure contours as discussed above.

6. Inventories and Valuations. The value of the existing system must be known if the economics of serving new customers is to be determined with any reasonable degree of accuracy. This is particularly true of large consumers, so located that a considerable investment in supply mains is involved. To serve such a consumer in small or medium sized cities may cause serious complication in the existing system unless special provision is made to supply the demand and since this may involve supply and storage as well as mains, the importance of the economic phase of the problem is quite evident.

The foregoing data which must of course be in the form of estimates as far as undeveloped territory is concerned, plus common sense and some hydraulic tables, about cover the field of distribution system extension as far as adequate capacity is concerned. Materials, methods of construction and the ever present question of elevated storage versus increased main sizes, are other problems which lend themselves still less to general analysis, but which constitute interesting studies in individual cases. When the additions are to be made in residential district, particularly in newly laid out sections, the "dual" system of mains is often worthy of consideration and where old parts of the system in highly developed districts must be reinforced, the matter of alignment usually becomes the controlling factor.

Recent trend in distribution system design favors the use of elevated storage at strategic points for pressure equalization and while this practice has its economic limits, it seems a step in the right direction. The necessity of maintaining high fire pressures has been reduced quite materially in the past few years by the more general use of steamer hydrants and gasoline driven pumpers. These and other features which go to make up what is termed "standard practice" in water distribution enter each individual problem to a greater or less extent and must be decided on merits in individual cases.

The various ramifications of a distribution system, its design, construction operation and extension are too numerous even for mention in a paper of this length, and the entire subject matter may be summed up in the phrase "Know Your Distribution System." The

various items mentioned herein as being necessary for rational design of additions will be recognized by water works men as data badly needed in other phases of operation and the collection of these data as a routine matter, is highly advisable aside from the matter of extensions and additions to the system.

In systems of considerable size, it is evident that the collection and assembly of the data as outlined as well as the making of the inventory and valuation involves a considerable amount of time and expense, but it is also evident that its cost is less if handled as a routine procedure than as an individual job done against time.

The distribution system, after all, is the backbone of the water works, and its extension along reasonable and economical lines is of such vital importance that the cost of rational planning is well justified, whatever that cost may be.

(*Presented before the Southwest Section meeting, October 14, 1935.*)

PURIFICATION PLANT AT TWO RIVERS, WISCONSIN

By E. J. Donnelly

(*Superintendent of Water, Two Rivers, Wisc.*)

The City of Two Rivers with a population of 11,000 people began the construction of a two million gallon filter plant in August, 1934, with a grant from the P.W.A. The plant was finished in May, 1935 at a cost of approximately $110,000.00. The bonds were sold at 3.9 percent in Chicago, the City's share of the cost being spread over a 20 year period.

On the same P.W.A. grant a half million gallon elevated storage tank was constructed costing $27,500.00, a 14-inch river crossing over 500 feet long was laid 14 feet deep costing $8,000.00 and about 1 mile of 12-inch main through the city to the elevated tank was laid replacing a 4-inch main costing $11,000.00. The Federal Government grant on these projects ran to approximately $50,000.00.

SOURCE OF SUPPLY

During the early growth and development of the city of Two Rivers, the water supply was obtained from wells, similar to Manitowoc and other cities at present. Gradually this supply decreased with increased consumption and it became necessary to secure a larger source of supply. It was only natural for the city to turn to Lake Michigan where an inexhaustible and cheap water was obtainable. Before the sanitary facilities of Two Rivers and Manitowoc were developed to a point where large quantities of sewage were discharged into the lake daily, this source was rather reliable, fulfilling the requirements of a good public water supply. Since that water does not have to be raised from a well to the surface of the ground, it is less costly to pump. The supply is unlimited in quantity, of good taste, has a hardness of between 7 and 8 grains per gallon, and contains iron in such small quantities that only very careful chemical analyses can detects its presence. The water taken from wells near Lake Michigan contains as high as 35 to 40 grains of encrusting solids per gallon. This lake water, therefore, has all the requirements of a good water for domestic consumption.

At first only a very short intake or pipe line was laid into the lake through which the water was pumped. With the growth in population, pollution increased and the intake was extended farther into the lake. The present intake used by the city is 24 inches in diameter extending 6000 feet into the lake where there is a water depth of 38 feet. Gradually the zone of pollution reached the end of this intake and it became necessary to apply chlorine to destroy harmful bacteria. While chlorination destroys bacteria, it does not remove sediment and causes a somewhat disagreeable taste, so ammonia was added later to prevent bad tastes to some extent. Were this intake extended farther into the lake, there would be no assurance that a safe supply could be obtained, since recent investigations by the United States Public Health Service indicate that the zone of pollution may extend many miles from shore. The people might have continued without a filter plant for several years, but for the bad tastes for a few weeks in the summer and the roily water in the spring and the intestinal disturbances in children which local doctors said was caused by raw water.

For several years the city officials studied the problem of securing an adequate and safe supply, meeting the requirements of present day standards for domestic water. These studies resulted in the decision to construct a rapid sand filtration plant similar to the many plants in operation on the shore of Lake Michigan. It has been conclusively proven in the cities of Sheboygan, Racine, Kenosha, Evanston, Waukegan, Lake Forest, Highland Park, Glencoe, and other cities along the lake that a filtration plant treating lake water will remove all bacteria, sediment and other impurities, producing an excellent water for domestic consumption and industrial use, exceeding in quality that obtained from wells, at no greater cost.

The present intake, 24 inches in diameter, is used to bring the water from the lake into an intake or shore well by gravity. One of three electrically driven centrifugal pumps pumps the water from this intake well and starts it on its journey through the plant. Two pipe lines lead from the well to the pumps as a measure of safety, the piping connections to the pumps being so arranged that any pump may be used on a suction line.

At present one 400 gallon per minute pump and two 800 gallon per minute pumps have been installed with space provided for an additional future unit. The installed pumping capacity is approximately equal to double the present water consumption. One of

these pumps may be taken entirely out of service without affecting the rated capacity of the plant.

As the water leaves the pumps, it passes through a meter where the rate of flow is indicated, recorded and registered.

TREATMENT PLANT

The low lift pumps discharge into a channel commonly referred to as the fore-bay of the mixing tanks. By opening or closing valves or sluice gates, the water is allowed to pass through the mixing tanks. As the water passes from the pumps to the fore-bay, ammonia is added. In the fore-bay chlorine and sulphate of aluminum are added.

The water as it enters the plant is turbid, colored and contains bacteria. The turbidity is due to finely divided matter held in suspension. It is usually too light to settle unless allowed long periods of time. Color, taste and odor in our water are in part caused by the decomposition of vegetation, bacteria and other organic matter. Ordinarily the largest part of these impurities can be removed by the use of a coagulant (sulphate or aluminum). This coagulant is precipitated out as an insoluble compound and removed by settling and filtration.

The chlorine added to destroy bacteria is applied to the unfiltered water to secure greater safety. Generally we add from 1 to 5 pounds of chlorine to sterilize one million gallons of water. The amount applied varies, depending upon the quality of the water as it enters the plant and is determined by daily laboratory tests. When chlorine is applied as you people know, the water has a chlorinous taste. To counteract this taste and at the same time not destroy the effectiveness of the chlorine, we add ammonia in the form of gas. It is applied with equipment similar to that used for chlorine. The optimum ratio of chlorine and ammonia generally lies between 4 and 8 parts of chlorine to one part of ammonia. Chlorine and ammonia are applied separately and chloramine is formed in the water. Chloramines are tasteless, but the death rate of bacteria resulting therefrom is somewhat slower, making longer contact periods necessary. The residual remaining after chlorination is removed by sedimentation and filtration.

During certain period of the year the water has a fishy taste caused by algae growths and microörganisms. This taste is further removed by adding activated carbon in powdered form to the water in the

fore-bay of the mixing tank. These tastes are absorbed by the carbon and the carbon settles out in the coagulation basins. During a time of very bad tastes we mix carbon directly into the coagulation basins also.

The water with the coagulants added passes from the fore-bay into the mixing tank. There are two tanks each providing for a 30-minute mixing period. Each is provided with electric driven paddles or flocculators to agitate and assist in thoroughly mixing the coagulant with the water. There are two mixing tanks so that one may be cleaned without interrupting the process. The rate of discharge from the pumps to the mixing tanks is controlled automatically by a water level control so that when the rate of filtration is reduced, the pumping rate is also automatically reduced. The mixing process is continuous and is accomplished in the water traveling through the mixing tanks from which it is discharged into the coagulation basins.

The coagulation basins or settling tanks, two in number, are rectangular units of sufficient capacity to provide a four hour settling period. These tanks are so arranged that either or both may be used. We have this flexibility so that a tank may be cleaned without interrupting service. The floc or gelatinous precipitate formed in the mixing tank settles to the bottom, carrying with it mud, bacteria, and other suspended matter. We plan to clean these tanks twice a year.

After passing through the coagulation basin, the water is ready for filtration. There are four sand filters, each capable of filtering at a normal rate of 500,000 gallons per twenty-four hours, but it is possible for short periods to filter at a 700,000 gallon rate per filter. Each filter is provided with a strainer system covered with 14 inches of graded gravel which supports 30 inches of specially graded filter sand. In each filter there are three wash water troughs which carry the wash water from the filters during the washing process.

A control table made of marble upon which are mounted the various controls used in operation is provided for each filter. Indicators recording rate of flow and loss of head gauges are mounted on each table. These gauges indicate and record the performance of each filter so that the operator can increase or decrease the rate of filtration as the consumption varies. The loss of head gauge is important because it indicates whether or not a filter is operating satisfactorily and normally. The loss of head should rise gradually throughout the time the filter is in use. When that loss reaches a

predetermined point, the operator knows that the filter is dirty and requires washing. The tables are mounted above the filter on the operating floor.

The water after passing through the filter is collected by the strainer system, conducted to the clear water reservoir and ready for consumption. This reservoir has a capacity of approximately 200,000 gallons. The present high lift pumps are connected to this unit and pump the water from it into the city's distribution system.

The plant has a modern laboratory containing the necessary equipment for making such tests as will indicate the purity of the water. Before we had our laboratory samples were sent to the State Board of Health at various intervals. This condition exists in all cities without filtration plants and unless the water is chlorinated, the supply may become contaminated in a few hours. Last summer in one of the largest cities in Wisconsin using a well water supply, contamination developed and before corrective measures could be taken many cases of dysentery developed. In a filtration plant this can rarely occur. Daily analysis are made on both the water as it comes from the lake and as it leaves the filter. Thus the operator has definite knowledge of the character of water being treated and these tests are an index for the treatment. Because daily laboratory tests are conducted, it should be virtually impossible for an impure water supply to reach a consumer at any time.

Two Rivers went through the usual period of educating its people not to believe the filtered water burned the grass and was not harder to boil and did not take any more soap than the raw lake water. One body, however, we could not seem to educate to our way of thinking was the Public Service Commission. In setting our hydrant rental rates they claim that filtered water ready for service is worth $100 at each hydrant instead of $80 which the Utility previously charged the city. Their argument is that this must be done as the investment cost of the entire plant is greater than before.

The cost of filtering, figuring depreciation, interest, taxes, etc., is $56.20 per million gallons based on the first five months of operation from May 7 to October 7. Our city uses an average of about 60 gallons of water per capita per day.

I want at this time to express my thanks to Mr. Zufeld of this city who gave us advice, and to the Jerry Donohue Engineering Company who were our engineers on design, construction and inspection.

(*Presented before the Wisconsin Section meetings, November 6, 1935.*)

THE COMPARATIVE STUDY OF NINE PRESUMPTIVE TEST MEDIA[1]

By Michael A. Farrell

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Lactose broth as recommended by the "Committee on Standard Methods" as a presumptive test medium for the detection of the coli-aerogenes group of bacteria in water has been under fire for a number of years. The main cause for dissatisfaction is the claim that lactose broth often gives a large percentage of positive presumptive tests that will not confirm. For this reason other presumptive test media have been developed. The names of these media and the abbreviations employed in this paper to facilitate the presentation of tabular material are listed below:

1. Lactose broth—S. L. (Standard Methods, 1933)
2. Buffered lactose broth—B. L. (Ruchhoft et al., 1931)
3. Brilliant green lactose bile broth 2.0 percent—B. G. (Jordan, 1927)
4. Fuchsin lactose broth—F. L. (Ritter, 1931)
5. Methylene blue-brom-cresol purple broth—M. B. (Dominick and Lauter,[2] 1929)
6. Crystal violet lactose broth—C. V. L. (Salle, 1930)
7. Formate ricinoleate broth—F. R. (Stark and England, 1933)
8. MacConkey's peptone lactose bile broth—P. L. B. (MacConkey, 1908)
9. Trypaflavine broth—Tryp. (Ruhmekorf, 1931)

These new presumptive test media were introduced and recommended on the basis of tests made between standard lactose and the newly proposed medium. With the continued development of new media it was essential that comparisons be made between these newly suggested media and standard lactose under identical conditions. A few such comparisons have been made.

[1] Authorized for publication on January 25, 1936, as paper No. 723, in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] Revised formula.

Horwood and Heifetz (1934) ran simultaneous tests of five pure cultures of the coli-aerogenes group of bacteria and sixty mainly unpurified water samples on standard lactose broth, crystal violet lactose broth, methylene blue-brom cresol purple broth and brilliant green lactose bile broth. On the examination of pure cultures they found the sensitivity of these media to be of the following order: Standard lactose broth, brilliant green lactose bile broth 2.0 percent, methylene blue-brom cresol purple broth, and crystal violet lactose broth. On the water samples the standard lactose broth was again most efficient while methylene blue-brom cresol purple broth and brilliant green lactose bile broth both yielded a greater percentage of confirmations.

Shunk (1935) investigated the sensitivity of 201 strains of the coli-aerogenes group isolated from feces on standard lactose broth, brilliant green lactose bile broth, fuchsin lactose broth, and crystal violet lactose broth. When small inocula, less than 50 organisms per cubic centimeter were seeded into these media, the order of sensitivity was: Standard lactose broth, brilliant green lactose bile broth, crystal violet lactose broth, and fuchsin lactose broth.

Stark and Curtis (1935) in a comparison of several presumptive test media claimed certain disadvantages for methylene blue-brom cresol purple broth, crystal violet lactose broth and brilliant green lactose bile broth in that the first medium would not grow small numbers of colon organisms and that they all showed gas production when inoculated with lactose fermenting anaerobes.

Ruchhoft and Norton (1935) report an extensive study of 60 cultures[3] of the coli-aerogenes group in which the desirability rating for seven presumptive test media was found to be as follows: Standard lactose broth, fuchsin lactose broth, buffered lactose broth, methylene blue-brom cresol purple broth, brilliant green lactose bile broth, crystal violet lactose broth and formate ricinoleate broth. As a result of this work they advocate a study of the more inhibitive media for use in confirmation procedure.

These few comparisons of several of the better known presumptive test media made essentially with pure cultures of the coli-aerogenes group of bacteria, have not greatly clarified the problem with regard to their respective efficiencies in the detection of the colon group in water. For this reason this investigation of seven of the more widely

[3] Certain of the twenty-three cultures of the coli-aerogenes group reported in this paper were included in the above collection.

used and generally accepted presumptive test media was undertaken. In addition MacConkey's peptone lactose bile broth and Klimmer's modified trypaflavine broth were included. The former because of its general acceptance as the presumptive test medium in England and the latter because of the favorable acceptance it has received in Germany.

METHODS

This study is divided into three parts: I. The determination of the relative abilities of these nine presumptive test media in the detection of pure cultures of the coli-aerogenes group. II. The inhibitiveness of these media for aerobic and anaerobic spore forming rods which ferment lactose. III. The analysis of 100 water samples employing these nine media.

MEDIA

The first seven media listed at the beginning of the paper were obtained in dehydrated form from the "Difco Laboratories." These media had been specially prepared for the "Committee on Standard Methods of Water Analysis," and were verified as being up to the specifications of their proponents.[4] Peptone lactose bile was prepared according to MacConkey's (1908) formula and trypaflavine broth after the formula of Ruhmekorf (1931).

I. THE RELATIVE EFFICIENCY OF NINE PRESUMPTIVE TEST MEDIA IN THE DETECTION OF PURE CULTURES OF THE COLI-AEROGENES GROUP

The twenty-three strains of colon organisms used in this study were isolated from water, milk and human feces. Grouped according to their biochemical characteristics, ten cultures were found to belong in the genus *Escherichia*, six cultures in the genus *Aerobacter* and the remaining seven cultures were intermediate strains.

Procedure. The method adopted for the determination of the coli-aerogenes productivity was that of Butterfield (1933) and Hoskins (1933). The data presented have been computed on the basis of the total number of tubes showing gas, regardless of dilution. The total

[4] The proponent of each medium was asked by the "Committee" to make comparisons of his own and the dehydrated product prepared by the "Difco Laboratories" in order to ascertain that the dehydrated product met the proponent's specification.

number of tubes of standard lactose broth showing gas within 48 hours is given a value of 100. The value of the other media is calculated as percentage of lactose broth positives, and shows the relative sensitivity of each medium in the detection of small numbers of the coli-aerogenes group when present in pure culture. The results obtained upon inoculating these twenty-three pure cultures of the coli-aerogenes group into the nine presumptive test media are shown in table 1.

It is evident from table 1 that standard lactose broth and fuchsin lactose broth are almost equally productive for these twenty-three cultures. Buffered lactose broth and brilliant green lactose bile are slightly over 90.0 percent as sensitive as the standard medium. The

TABLE 1

Showing the relative efficiencies of nine presumptive test media in the detection of twenty-three pure cultures of the coli-aerogenes group in nine presumptive test media

BROTH MEDIUM	TOTAL NUMBER OF POSITIVE TUBES	PERCENTAGE OF LACTOSE BROTH POSITIVES	DESIRABILITY RATING
Standard Lactose	565	100.0	1
Fuchsin Lactose	552	98.0	2
Buffered Lactose	512	90.6	3
Br. Green L. B.	509	90.1	4
Peptone Lactose B.	145*	85.0	5
M. B.–B. C. P.	429	76.1	6
Crystal Violet L.	420	74.4	7
Trypaflavine Lactose	43†	53.0	8
Formate Ricinoleate	214	38.0	9

* Data on sixteen organisms.

† Data on four organisms.

remaining media show a sharp decline in percentage sensitivity indicating the inhibiting tendency of these media for small numbers of the coli-aerogenes group.

II. STUDIES OF THE ABILITY OF AEROBIC AND ANAEROBIC LACTOSE FERMENTING ORGANISMS TO GROW IN THESE PRESUMPTIVE TEST MEDIA

Spore-forming bacteria that ferment lactose are often responsible for false presumptive tests. In a comparison of media to be used to detect water pollution, it is of primary interest to determine the ability of these organisms causing false presumptive tests to grow in these newly suggested media. Using the same procedure previously

described for determining the efficiency of these media in the detection of small numbers of coli-aerogenes organisms, two cultures each of *Cl. tertium* and *Cl. welchii* and five cultures of aerobic lactose fermenting organisms[5] were planted into these presumptive test media. Anaerobiosis was obtained by having a greater depth of medium, 20 cc. per tube, which was heated to boiling and cooled prior to inoculation. Table 2 shows the relative abilities of these media to prevent the growth of these spore-forming organisms.

Table 2 shows that all the presumptive test media containing dyes or other inhibitory substances, except methylene blue-brom cresol purple broth, readily inhibits the growth of small members of aerobic spore forming rods which ferment lactose with gas production. The

TABLE 2

The inhibitory action of eight presumptive test media on spore-forming organisms responsible for false presumptive tests

	SPORE-FORMING BACTERIA	MEDIUM							
		F.R.	C.V.L.	F.L.	P.L.B.	B.G.	B.L.	M.B.	S.L.
Total number of positive tubes	Anaerobic	0	0	5	10	11	16	21	31
	Aerobic	0	0	0	0	0	122	7	56
Percent of lactose broth positives	Anaerobic	0	0	15.2	32.2	35.5	51.6	68	100
	Aerobic	0	0	0	0	0	218	12.5	100
Desirability Rating	Anaerobic	1	2	3	4	5	6	7	8
	Aerobic	1	2	3	5	4	8	6	7

anaerobic spore formers, however, showed gas production in from 15 to 68 percent of the 180 tubes employed, with fuchsin lactose broth, peptone lactose bile (MacConkey's), brilliant green lactose bile and methylene blue-brom cresol purple broth. The desirability rating of these media in the inhibition of both anaerobes and aerobes is essentially the same for the first five media.

III. THE ANALYSIS OF 100 WATER SAMPLES EMPLOYING NINE PRESUMPTIVE TEST MEDIA

The foregoing experiments and results involving pure culture studies on these media have been criticized in that they are not the

[5] The author wishes to thank J. K. Hoskins and C. T. Butterfield for these aerobic cultures.

actual conditions met with in water analysis, where many bacterial species may be present as well as a certain amount of organic matter which might materially influence the results in those media containing dyes and other inhibitory substances. In order to determine whether these presumptive test media would have the same relative efficiencies in the detection of the coli-aerogenes group when water samples were analyzed as when pure cultures were employed, one hundred water samples from different sources were analyzed. Twenty-six of these samples were surface waters obtained from small streams in the vicinity of State College, Pennsylvania, while the remaining seventy-four were mainly deep wells with a few cisterns and springs. The procedure followed was to perform a presumptive test of each water sample with all nine presumptive test media. The results of these nine presumptive tests on each water sample were then separately carried through the partially confirmed and the completed tests according to "Standard Methods" procedure. The amount of water planted into each medium for the presumptive test was five 10-cc. portions, two 1.0-cc. portions and two 0.1-cc. portions. The 10.0-cc. portions of water were planted into 10 cc. of double strength medium in the case of all nine media, while the other portions were cultured in single strength medium. Gas formation was noted within 24 and 48 hour incubation periods. The highest dilutions showing gas formation were streaked onto eosine-methylene-blue agar plates (Levine Formula). Typical and atypical colonies were then picked from these plates to complete the test.

The twenty-six surface waters were grossly polluted and in all nine presumptive test media except trypaflavine broth the presence of the coli-aerogenes group was readily demonstrated. The seventy-four well water samples containing smaller numbers of this group of bacteria lend themselves better for comparative purposes as is shown in table 3.

Table 3 shows the number of positive and doubtful presumptive tests obtained when seventy-four samples of well water were planted into seven presumptive test media. The largest number of samples showed gas formation in formate ricinoleate broth followed by standard lactose broth, fuchsin lactose broth and buffered lactose, brilliant green lactose bile, methylene blue brom cresol purple broth with crystal violet lactose broth, showing the least number. The number of partially confirmed tests is in most instances, with the exception of formate ricinoleate broth, approximately 50.0 percent of

the number of positive and doubtful presumptive tests. The number of positive completed tests indicating the presence of the coli-aerogenes group shows the largest number is obtained with standard lactose broth followed by fuchsin lactose, brilliant green lactose bile, methylene blue-brom cresol purple broth, buffered lactose broth, formate ricinoleate broth, and crystal violet lactose broth.

In the interpretation of the data presented in table 3 the question as to whether it is desirable to have a medium which is more sensitive to small numbers of colon organisms present in the water which at the same time gives a certain number of false presumptive tests or a medium which while not as sensitive to small numbers of colon organisms does away with a certain number of false presumptives is

TABLE 3

Results of the analyses of seventy-four samples of well water utilizing seven presumptive test media, followed by standard procedure

	MEDIUM						
	S.L.	B.L.	B.G.	F.L.	M.B.	C.V.L	F.R.
Number of positive and doubtful presumptive tests	43	42	37	43	35	28	48
Number of partially confirmed tests.	23	19	18	20	19	12	16
Number of completed tests which were positive	32	27	29	31	27	22	25
Percent of presumptive tests which on completion were positive	75.2	64.3	78.4	72.1	77.1	78.6	54.2
Percent of standard lactose presumptives completed	100.0	84.4	90.6	96.9	84.6	68.8	78.1

again brought to the fore in presenting the following data. Calculated as percentages of presumptive tests which upon completion were positive, it is seen that in table 3 crystal violet lactose broth and brilliant green lactose bile are the most efficient media. These are closely followed by methylene blue-brom cresol purple broth, standard lactose broth and fuchsin lactose broth while buffered lactose broth and formate ricinoleate are at the end of the list. This method of comparison cannot be called accurate when it is noted that only 22 of these 74 well waters would be found to be polluted by the use of crystal violet lactose broth, whereas 32 were found to be polluted with the use of standard lactose broth. The fifth set of figures in table 3 offers a fair comparison of these six other media with standard lactose broth. Giving it a value of one hundred, it is noted that the order of

efficiency in the detection of the coli-aerogenes group of the other presumptive test media are fuchsin lactose broth, brilliant green lactose bile, methylene blue-brom cresol purple broth, buffered lactose broth, formate ricinoleate broth and crystal violet lactose broth. This method of comparison places the medium which was first, according to percent of positive presumptives which were completed, last.

The above results coincide very closely with the order of desirability found for these media in this study when pure cultures of the coli-aerogenes group were studied. These findings indicate that the objections raised to the procedure followed in evaluating the relative merits of presumptive test media by pure culture studies are not valid.

The data obtained in the presumptive test when these 100 water samples were planted in multiple portions, for each of the three dilutions employed, offered a comparison not only of the presence or absence of the coli-aerogenes group in these water samples but when present showed the density of the colon group of organisms. Presuming that gas formation was caused by the coli-aerogenes group of organisms alone, the most efficient medium would be that one which showed the highest most probable number (M.P.N.) per cubic centimeter.

In order to observe the density picture obtained in the different media, the M.P.N. values for the combination of tubes showing gas formation in the three dilutions employed was calculated using the simplified mathematical treatment suggested by Hoskins (1933[6]). The average M.P.N. per 100 cc. of water for each medium on the two types of water are shown in table 4.

Table 4 shows the average M.P.N. value of these 26 surface waters on these nine presumptive test media after 48 hours incubation. A similar tabulation for 24 hours shows a lower M.P.N. but a similar trend. These highly polluted surface waters averaged between 400–600 organisms per 100 cc. of water as the M.P.N. of coli-aerogenes present. This number of colon organisms (4–6 per cubic centimeter) is sufficient inoculum as was shown in the pure culture studies of the colon group in this paper, to produce fermentation in those media which are inhibitory when one or less than one colon organism is present. The variation in the averages of the different media on this

[6] The writer wishes to express his thanks to J. K. Hoskins for assistance in making these calculations.

number of samples does not appear significant except in the case of trypaflavine broth which has a definite inhibitory action.

The average[7] M.P.N. for the 74 samples of well water shows that fuchsin lactose broth and standard lactose broth had the highest M.P.N. values with 78 and 74 organisms per 100 cc. respectively. These are followed by formate ricinoleate broth and green lactose bile broth with M.P.N. values of 53 and 52. The most probable number of organisms for the remaining media is considerably less with crystal violet lactose broth showing less than 50.0 percent of the value obtained with the standard medium. The M.P.N. for MacConkey's peptone lactose bile broth and trypaflavine broth have not been calculated as they were used only in the analysis of 42 and 54 of the water samples respectively. Unfortunately little comparison can be made with the former medium in this instance but with the trypaflavine

TABLE 4

The average most probable number of colon organisms in 100 water samples, employing nine presumptive test media

	AVERAGE M.P.N. PER 100 CC. OF WATER								
	Medium								
	S.L.	B.L.	F.L.	B.G.	M.B.	C.V.L.	F.R.	P.L.B.	Tryp.
26 Surface Waters.....	522	600	541	567	443	602	415	400	125
74 Well Waters.....	74	46	52	78	48	31	53		

broth it will be observed that it is definitely inhibitory in the high percentage of water samples, 44 out of 52, which show no signs of pollution.

DISCUSSION

The results obtained in this study comparing the relative abilities of nine presumptive test media to detect small numbers of pure cultures of the coli-aerogenes group and the relative efficiency of these media when 100 water samples were analyzed showed that the same media were best able to detect the presence of coli-aerogenes group members whether pure cultures or water samples were studied. The objections

[7] It is realized that averaging data obtained by using an uneven number of tubes in the three portions of water tested is open to criticism. Other statistical treatments are open to more severe criticism and the averages are presented here as showing a summary of the indicated trend.

raised with regard to the value of pure culture studies alone in comparing presumptive test media therefore do not appear valid from this investigation.

It appears from this work that the ability of the various presumptive test media to detect the presence of the coli-aerogenes group in water is determined by the number of these bacteria present. In the study of pure cultures of colon organisms employing the highest of the three dilutions (Butterfield-Hoskins technique) as well as where the M.P.N. values were calculated for the surface and well water samples, it was evident that there was no difference in the ability of eight of these presumptive test media to detect the presence of the coli-aerogenes group when 4 to 10 organisms per cubic centimeter were present. (See table 4.) When the critical dilution in the Butterfield-Hoskins technique, or the 74 well water samples were considered and where the number of organisms averaged in the neighborhood of one or less than one per cubic centimeter then certain presumptive test media such as standard lactose broth, fuchsin lactose broth, brilliant green lactose bile and buffered lactose broth appeared more efficient in the detection of the small numbers of colon group members than the remaining media.

An attempt to obtain a presumptive test medium with the property of being most efficient in the detection of the coli-aerogenes group, one which will prevent false presumptives caused by organisms other than colon lactose fermenters or those responsible for synergistic actions, and one that permits the selective culturing of coli-aerogenes organisms over many other diverse mixtures or organisms under a variety of water conditions appears a hopeless task. This paper shows that the media studied fall into two groups with regard to their sensitivity to small numbers of the coli-aerogenes group, both in pure culture study and in the examination of water samples. The first group of media, including standard lactose broth, fuchsin lactose broth, buffered lactose broth and brilliant green lactose bile broth, while being the most efficient at the same time permit the growth of organisms other than colon members. The second group of culture media, while definitely inhibiting these non-colon strains, also prevents the growth of approximately 20.0 percent of the coli-aerogenes organisms present. If this evidence is true, i.e., that it is not possible to develop a medium which will have the same ability to detect coli-aerogenes members as standard lactose without at the same time permitting the growth of certain other organisms which may be re-

sponsible for gas formation, the hope expressed by Winslow (1935) for a primary fermentation test which could be accepted as final does not appear imminent.

While the hope of determining the potability of water from the presumptive test alone does not appear feasible with any of the presumptive test media used in this study, the determination of the coli-aerogenes density (M.P.N.) employing a larger sample as well as a larger number of duplicates for each dilution as suggested by Hoskins and Butterfield (1935) and Winslow (1935) appears to warrant further investigation with regard to giving a more accurate picture of the density of the coli-aerogenes group and the satisfying of the present "Treasury Standard" (1925). The accumulation of sufficient data along these lines may lead to the simplification of this standard, and to its general adoption for all types of water other than those supplied by common carriers for interstate commerce.

SUMMARY

Standard lactose broth was the most sensitive of the nine presumptive test media employed in the detection of small numbers of the coli-aerogenes group of bacteria, both in pure culture study and in the determination of the colon group in water samples.

Fuchsin lactose broth was found to be almost as efficient as standard lactose broth as a presumptive test medium. It was practically as efficient as the standard medium in the detection of small numbers of the coli-aerogenes group both in pure culture study as well as in the examination of water samples, and in addition, it markedly inhibited the growth of aerobic and anaerobic spore forming organisms which ferment lactose.

Brilliant green lactose bile broth and buffered lactose broth while showing 90.0 percent the productivity of standard lactose broth were found to have certain disadvantages and no advantages not possessed by fuchsin lactose. The remaining five media were found to possess a definite inhibitory action for small numbers of the coli-aerogenes group of organisms both in pure culture study and in the examination of water samples.

The calculation of the M.P.N. values for the three water portions employed showed that fuchsin lactose broth and standard lactose broth gave the highest index values.

The possibility of obtaining a perfect presumptive test medium and the questions regarding interpretations of data are discussed.

The writer gratefully acknowledges the assistance of Mr. J. W. King in performing certain of these experiments.

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WATER PURIFICATION DIFFICULTIES WITH SPORE-FORMING BACTERIA AND HIGH CONCENTRATION OF ORGANIC MATTER

By P. W. Frisk

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Since the rayon process requires a highly purified water, every precaution and means is applied to obtain and maintain a high quality of water. This paper will give a brief discussion of some of the new experiences encountered in treating a seven year reservoir supply to make this water acceptable to the rayon industry.

One of the sources of water for the American Enka Corporation, rayon manufacturers, is Lake Enka, a reservoir having a capacity of 300,000,000 gallons. This reservoir is fed by a number of fresh water streams with the added facility of pumping water from the Hominy Creek into the reservoir. This assures a maintenance of water level and supply. During extremely rainy periods when there may well be an excess of water as fed naturally into the lake, pumping from the lower Hominy Creek is not necessary.

Since the water which is treated is first used for condensing purposes, it was necessary during the Summer of 1935 to take the water from a lower depth than heretofore, a new depth of 14 feet. This water was some 10°C. cooler and afforded sufficient cooling capacities for the condenser. The water temperature from the condenser increased, the final temperature being approximately 35°C. The water at this temperature was required to be treated to remove the turbidity, color, metal, and organic matter. The treatment as given this water was to coagulate with alum and lye, oxidize the manganese with $KMnO_4$, and eliminate the organic matter and microörganisms with chlorine. This method of treating the lake water has resulted in the satisfactory removal of turbidity, color, iron, and manganese.

For the past three years, we have been dosing our reservoir with chlorine and ammonia at the ratio of 1–3 and with a total dosage of 150 pounds chlorine to 50 pounds anhydrous ammonia per day.

Our chlorine test, after subtracting the manganese, has shown a residual over the large area of the lake to be about 0.00–0.10 p.p.m. and the residual test on raw water entering the filter plant some three-quarters mile away has shown the presence of 0.0–0.1 p.p.m.

The dosage of the reservoir with chlorine and ammonia has proven its good effects. We are quite certain that this preliminary chlorination suppresses to a certain degree the growth of organic matter and microörganisms in the water.

During the Fall of 1934 we did not have sufficient opportunity to bleed off the bottom of the reservoir before the usual turnover. Consequently, a considerable quantity of organic matter, iron, and manganese remained. In the Spring of 1935, beginning as early as April, we began to give a copper sulphate treatment, which continued at intervals of every 14 days during the Summer. The dosage was restricted somewhat on account of the stock bass which we had placed in the lake several years ago. However, we could treat our water up to 0.14 p.p.m. $CuSO_4$ before affecting many of the fish.

In spite of our chlorine and copper sulphating, we apparently were not able to effect the condition of the water some 14 feet below the surface. Starting about May 28, it became difficult to maintain a residual chlorine and, after a few tests, we found the chlorine demand was due to organic and microörganisms. Up to this time, we had a chlorine dosage of 1.0 p.p.m. with a residual of 0.3 p.p.m. It became necessary to bring the dosage up to 4.75 p.p.m., in order to have a residual of 0.2–0.3 p.p.m., the temperature of the water being about 30°–32°C.

The arrangement we have for mixing our chemicals is over and and under type baffles with 125,000 gallon settling basin. The sun was extremely bright during May and June, which, no doubt, had its influence on dissipating part of the chlorine in the settling basins. However, in order to prove whether we were having such losses, we decided on June 29 to apply chlorine and ammonia, the latter being fed as $(NH_4)_2SO_4$ and mixed in with the alum solution and fed as such. We immediately were able to reduce our chlorine from 4.75 to 2.64 p.p.m. on June 1 to 1.2 p.p.m. on June 29. We still maintained a residual chlorine on top of our filters of 0.5–0.7 p.p.m. Since we dechlorinate, it was possible to carry a high chlorine above the filters.

The change from normal 4 to 16 feet depth was not effective until July 16. When the final temperature of the surface water, after

passing the condenser, reached its peak of 35°C., shifting to a lower depth resulted in reducing the temperature to 27°C. The chlorine consumption was apparently not increased. The reason will be given later. The first appearance of manganese occurred on July 16, amounting to 0.22 p.p.m., which confirmed the results of other samples taken directly from the lake. A $KMnO_4$ dosage was started at 0.68 p.p.m. and the coagulating pH increased from 6.2–6.5 to 6.4–6.7. The oxidation and precipitation of manganese was 85 percent complete in the basins and gave no trouble in filtration.

About the middle of August we began to observe mud collecting on top of our settling basin and, likewise, in the lower entrance to the basins. This material appeared to be foamy with alum floc, but upon microscopic examination several types of microörganisms, including paramesium, hydria, worms were found. A later examination and culture revealed the presence of cellus substle, a spore-forming bacterium. We found a large amount of this gelatinous material collecting on walls of our settling and filtering basins. An examination of the sand and gravel in the filters showed an accumulation, which apparently was not being removed in the back washing. The results of this accumulation reduced the filter runs to only 8–10 hours, against the normal running time of 40–60 hours. The filter runs after lye treatment increased to a maximum of 107 hours.

This short running time of the filters had to be rectified. Some treatment had to be applied, which would remove this objectionable matter from the filters. We had tried out on a laboratory scale the soaking out and, consequently, cutting loose of this gelatinous material from the sand and gravel. These experiments were simple. Quart fruit jars were half filled with sand and various concentrations of lye. These jars were shaken and allowed to stand. After 24 hours, the lye was decanted and water added, shaken several times, the material removed and examined. The conclusions showed that a lye weaker than 5 percent required a longer contact time. It is quite possible that a 17.0 percent lye would give good results in 8–12 hours. From the results of these tests, it was, finally, decided to use caustic soda of approximately 5.0 percent strength. The filter was filled with this solution and allowed to soak for 24 hours. After 24 hours, the filter was washed three consecutive times with approximately 100,000 gallons of water. A tremendous amount of organic matter was removed.

After the lye treatment, we applied a chlorine sterilization treat-

ment, using soda bleach to the extent of 20–30 p.p.m. of available chlorine. The filter was filled with water to the bottom of the wash troughs. This allowed about 26 inches of water above the sand, in which the soda bleach could be mixed. The soda bleach-water solution, after mixed with water, was dropped down, so that only the top liquid was visible. This permitted the chlorine solution to reach the entire sand bed in which most of the gelatinous material had collected. Allowing 12 hours contact time, we were able to effect a good sterilization of the filters. Back washing was carried out and final re-wash period was approximately 6 hours. Samples were taken at intervals and checked for turbidity and pH. After the re-washing was completed as shown by the samples, the filter was again put back into service.

This type of treatment was carried out on all filters and proved to be very satisfactory in eliminating this objectionable matter. A second treatment has been necessary during the early part of October and was given to those filters appearing to have been reinfected with cellus substle. This cellus substle builds up a considerable resistance in the filter bed, reducing considerably the length of the filter run. Although a high chlorine content is carried in the water coming onto the filters, it does not seem to influence the accumulation or growth of these spore-forming bacteria.

In conclusion, it is not possible to prescribe a method for the complete erradication of cellus substle, except that pre-chlorination with chlorine and ammonia will suppress its growth. When a sand filter has a great accumulation of this material and the filter runs are reduced below practical limits, a cleaning treatment with caustic soda and soda bleach will restore the filter to its original capacity and efficiency.

Acknowledgment is made to the State Hygiene Laboratory for assistance in confirming our ideas on a possible method of removing this material from the filter beds and their sterilization.

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TREATMENT OF THE COLORADO RIVER WATER

By D. M. Forester

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The water of the Colorado River has been used for domestic consumption, in several small towns and cities, for many years and when clarified is satisfactory for drinking. This water is suitable for all domestic uses, but is harder than is considered satisfactory for public supplies. The first and the only community to successfully treat and soften the "run of the river" water was Boulder City, Nevada, the construction camp for the Boulder Canyon Project. It is generally considered that the Colorado River, in its lower reaches, was the flashiest, most turbulent and heaviest silt laden stream in the United States, or elsewhere, whose waters were then being treated for domestic and industrial use.

Studies made of the river, prior to the design of the water supply system at Boulder City, gave such wide ranges of suspended solids content as 350 to 60,000 p.p.m., of total hardness varying from 144 to 636 p.p.m., and of dissolved solids from 226 to 1516 p.p.m. During the period since March 2, 1932, when the system was placed in operation, the ranges have been even greater. At times variations of over 200 p.p.m. total hardness have occurred within a period of three hours.

The treatment plant at Boulder City was designed for a maximum capacity of 2 m.g.d. to treat a water averaging 210 p.p.m. non-carbonate and 158 p.p.m. carbonate hardness within the ranges given above. Such conditions required a plant with maximum flexibility to provide complete softening. The system included such features as plain pre-sedimentation, aeration, softening, recarbonation, filtering and disinfection and consisted of a pre-treatment plant at the river and the softening plant at Boulder City, 6.6 miles away. The pre-treatment plant, in addition to the pumping equipment, consists of a 55 feet square sedimentation basin with 11 feet side depth, equipped with rotating clarifier mechanism and diaphragm sludge pumps, and of sufficient size to permit a two and one-half hour detention at design flow. The effluent from this basin is pumped to

an intermediate pumping station and thence to the aeration unit and receiving tank at Boulder City.

The softening plant is so constructed that the water may be subjected to simple coagulation, partial or complete softening and the various units of the plant are so arranged to permit either series or parallel operation. At this plant there are two units or sections, each a duplicate of the other, consisting of two 14-foot square mixing basins equipped with rotating agitators, a 45-foot square clarification basin with 12-foot side depth equipped with clarifier mechanism, and a carbonation basin 8 feet wide, 60 feet long and 12 feet deep. The rapid sand filters are in four units each with a surface area of 127.5 square feet, with a sand depth of 36 inches underlaid with 18 inches of gravel. The flow through the softening plant is by gravity and after final treatment the water is pumped to storage. The total static head varies from 1955 to 2010 feet from the river's edge to the reservoir, depending upon the stage of the river and the amount of water in the reservoir.

The operation of the complete system, during average condition, required two men for each shift, an operator at the pre-treatment plant and one operator at the filtration plant, the intermediate pumping station being entirely automatic in operation. With a sump tank for the river clarifier effluent, a 90-foot surge tower and an ingenious system of controls and switches at the intermediate station, a receiving tank at the Boulder City plant and direct telephone connection between the operators, any desired rate of flow could be maintained.

The wide ranges in turbidity, suspended solids, total and non-carbonate hardness in the raw river water during the period the system was in operation and until February, 1935 when storage, in the reservoir began, all shown in tables 1, 2 and 3.

The general method of treatment was plain sedimentation at the river plant followed by excess lime and soda ash softening with series flocculation, sedimentation and carbonation. Due to the varied characteristics of the river water many variations of this general method were used, such as, excess lime alone, re-circulation of sludge, addition of alum and of ferrous sulphate to either or both primary and secondary mixing basins, the use of coagulants, alum, ferrous sulphate and lime, and lime alone at the pre-treatment clarifier. Parallel flow through the basins at the softening plant was also used at different times.

TABLE 1

	TURBIDITY		
	Average	Maximum	Minimum
April, 1932	9,000	16,800	5,000
May	4,000	2,400	6,400
June	1,300	2,500	800
July	4,200	20,000	1,000
August	11,500	49,000	1,600
September	26,000	150,000	2,100
October	6,000	20,000	1,500
November	900	7,500	800
December	900	1,300	600
January, 1933	500	700	400
February	500	1,000	300
March	3,600	13,000	550
April	2,400	3,700	1,500
May	3,800	7,600	800
June	1,800	3,200	1,000
July	10,100	29,600	650
August	19,500	40,000	8,400
September	26,850	87,000	4,400
October	21,200	60,000	4,600
November	1,900	5,000	1,200
December	3,000	9,200	1,100
January, 1934	1,300	3,700	650
February	800	1,050	600
March	1,100	1,700	850
April	1,800	6,800	700
May	2,700	5,200	1,200
June	2,900	19,000	350
July	1,400	30,000	45
August	11,000	31,000	140
September	45,000	130,000	6,000
October	8,800	45,000	1,300
November	1,400	2,700	900
December	1,800	5,000	1,300
January, 1935	5,700	25,000	1,200
Average for 34 months	7,200	150,000	45

TABLE 2

	SUSPENDED SOLIDS		
	Average	Maximum	Minimum
April, 1932	13,120	29,850	8,560
May	8,350	14,800	3,670
June	8,807	17,100	4,052
July	8,460	27,540	1,270
August	11,600	56,650	2,100
September	16,510	84,800	2,400
October	5,440	17,530	1,470
November	2,460	6,540	940
December	1,610	3,490	950
January, 1933	1,660	2,650	1,025
February	1,310	2,260	680
March	3,550	10,835	810
April	2,620	3,640	1,870
May	8,820	24,900	2,300
June	8,300	13,410	2,250
July	10,575	26,110	2,960
August	14,654	27,610	7,970
September	19,620	66,900	3,760
October	15,960	43,530	4,280
November	2,252	4,050	1,610
December	3,425	9,220	1,700
January, 1934	2,020	5,185	690
February	1,320	3,115	770
March	1,410	2,350	970
April	2,613	7,125	646
May	6,943	14,057	4,118
June	4,782	17,458	1,120
July	2,156	37,539	58
August	6,637	17,309	348
September	29,825	87,000	4,685
October	6,267	28,438	1,250
November	1,788	3,243	1,096
December	2,118	4,253	1,558
January, 1935	5,047	18,833	1,573
Average for 34 months	7,118	8,700	58

TABLE 3

Total and non-carbonate hardness

	TOTAL HARDNESS			NON-CARBONATE		
	Maximum	Minimum	Average	Maximum	Minimum	Average
April, 1932	365	189	258	193	69	115
May	233	94	156	115	12	45
June	140	100	113	54	0	21
July	524	124	238	431	27	134
August	714	220	352	554	120	224
September	904	405	564	651	237	407
October	568	450	529	395	288	348
November	571	482	521	365	279	317
December	589	518	554	383	312	345
January, 1933	640	532	601	400	304	358
February	563	465	499	321	249	282
March	500	404	453	307	224	261
April	443	350	397	256	177	216
May	429	157	297	256	35	145
June	166	105	126	46	35	37
July	500	122	271	386	42	159
August	720	310	435	579	166	280
September	665	470	551	515	314	390
October	680	450	538	533	296	380
November	655	575	609	467	375	420
December	720	475	623	535	303	421
January, 1934	685	540	587	497	344	390
February	610	510	564	416	340	378
March	520	433	471	352	253	294
April	460	339	406	288	176	237
May	318	168	219	171	68	105
June	335	176	260	198	80	144
July	453	337	400	301	186	256
August	830	443	589	691	294	429
September	700	550	587	543	369	432
October	760	540	655	582	372	474
November	805	610	664	602	422	474
December	893	575	696	688	371	485
January, 1935	645	430	557	441	242	360
February	590	440	528	390	250	333
March	460	393	435	266	207	245
April	420	295	360	236	153	198
May	295	230	259	155	113	129
June	240	190	213	116	80	99
July	210	160	171	102	64	73
August	165	140	158	75	50	68
	904	94		691	0	

MOST SATISFACTORY TREATMENT

Under practically every condition encountered during the period from March, 1932 to May, 1935 the most satisfactory softening and treating method was found to be through the following steps or series:

Lime and soda ash are applied at the same time to the raw water as it flows to the first mixing chamber. Thorough rapid mixing is followed by gentle agitation just sufficient to prevent precipitation and not sufficiently violent to break up the "floc" which forms. From the mixing basin the water passes over a full length weir into the primary clarifier for precipitation of the suspended solids, thence through the primary carbonation basin where sufficient carbon dioxide is added to convert the residual causticity into carbonates. From this basin the flow is to the second series of mixing basins where powdered activated carbon is added for taste and odor control. In the first of these mixing basins the agitation is much more gentle than in the mixing of the lime, soda ash and raw water. From these basins the water flows through the secondary clarifier for the precipitation of the carbon and carbonates, thence to the secondary carbonation chamber where sufficient carbon dioxide is added to convert all the carbonates to bicarbonates and with a small excess of free carbon dioxide. From the secondary carbonation basin the softened water flows to the filters.

In general the most satisfactory condition of the water as it flows from the various basins was found to be as follows:

The effluent from primary clarifier:

	p.p.m.
Total hardness	140 to 150
Non-carbonate hardness	40 to 60
Alkalinity, methyl orange	90 to 100
Alkalinity, phenolphthalein	70 to 90
pH	11.0 to 11.2

The effluent from primary carbonation basin:

	p.p.m.
Total hardness	100 to 120
Non-carbonate hardness	40 to 60
Alkalinity, methyl orange	50 to 60
Alkalinity, phenolphthalein	25 to 35
pH	9.4 to 9.6

The effluent from secondary clarifier:

	p.p.m.		
Total hardness	80	to	100
Non-carbonate hardness	40	to	60
Alkalinity, methyl orange	30	to	40
Alkalinity, phenolphthalein	15	to	25
pH	9.2	to	9.6

The effluent from secondary carbonation basin:

	p.p.m.		
Total hardness	90	to	100
Non-carbonate hardness	40	to	60
Alkalinity, methyl orange	30	to	50
Free carbon dioxide	0.5	to	4.0
pH	7.3	to	8.3

VARIATIONS IN TREATMENT

Many minor variations of the foregoing sequence of treatment were used with varying success. Some years ago investigators found that the sludge formed in the lime—soda ash treatment, when returned or re-circulated, had a value as a coagulant. The plant at Boulder City was designed for re-circulation of sludge from either or both clarification basins. Many attempts were made to utilize this feature of the plant. Fair results were obtained by re-circulating the sludge from and through the primary clarifier when using low grade, 56½ to 57 percent, soda ash, and the raw water, total hardness ranged around 525 to 550, the non-carbonate hardness from 315 to 335 p.p.m., suspended solids averaged about 80 p.p.m. with a turbidity of about 130 p.p.m. However, all attempts to re-circulate sludge from and through the secondary clarifier, even when it contained precipitated activated carbon proved failures in as much as the carbonate content of the effluent was never lowered below that secured by plain sedimentation and usually the re-circulated sludge increased the content from 10 to 30 p.p.m.

During periods when the non-carbonate hardness in the raw water would be quite high, 400 p.p.m. or more, difficulty was frequently encountered in securing the desired precipitation in the secondary clarifier. This was probably due to the high dissolved solids content which ran from 1300 to 1500 p.p.m. Various means were used in attempting to overcome this trouble. Alum, in various amounts, was

added ahead of the secondary mixing basin without appreciable or satisfactory results. Its use also lowered the length of the filter runs. Chlorinated copperas was tried and it did not appreciably reduce the carbonate content, although its use did not affect the filter runs. Ferric chloride was tried and gave about the same results as chlorinated copperas. Powdered activated carbon aided more in the reduction of the carbonate content than any other agent used and without any loss of its value in controlling taste and odor.

Various points of application of chlorine were used with varying success. Chlorine was often applied between the primary carbonation basin and the secondary mixing basins for algae control and to permit the use of ferrous sulphate without calcium hydrate. It was also applied to the filter effluent, to the plant effluent and the filter influent. Under average operating conditions the application to the filter influent proved most satisfactory and the activated carbon caught by the filters prevented chlorinous tastes and odors from reaching the distribution system.

During the months of August and September, 1932 the turbidity and suspended solids carried by the river were much higher and of quite a different quality than any condition contemplated in the original design of the system. The suspended solids during this period had a settling rate as low as 3 inches per hour in still water and with a rate of flow of 0.4 m.g.d. across the 55-foot pre-treatment clarifier the movement was sufficient to keep the solids in suspension. The reduction effected at this clarifier with detention period of ten hours, when the influent had a turbidity of 150,000 p.p.m. and suspended solids content of 84,400 p.p.m., was 64 and 36 percent respectively. The original design was a "straight across the basin" flow with both influent and effluent weirs of the overflow type 55 feet in length. Because of the very slow settling rate and the belief that an absolute minimum overflow depth on the weirs would give much more satisfactory results, the pre-treatment clarifier was equipped with a peripheral weir. The effectiveness of this method may be noted from the results obtained after its installation. With the influent having a turbidity of 130,000 p.p.m. and suspended solids content of 87,000 p.p.m. the turbidity of the effluent was 1500 p.p.m. and the suspended solids content 1006 p.p.m. with a rate of flow of 0.4 m.g.d. through the clarifier or a detention period of ten hours.

Some trouble from algae was encountered but its control was not difficult. Copper sulphate and chlorine both proved quite effective.

TABLE 4

	FLOW	TURBIDITY	SUSPENDED SOLIDS	TOTAL HARDNESS	NON-CARBONATE HARDNESS
	m.g.d.				
April, 1932	0.74	97.4	99.0	67.5	96.5
May	0.73	98.9	97.3	43.6	0.7
June	1.04	96.9	97.2	36.3	0.0
July	1.09	97.8	92.0	56.0	68.0
August	1.01	61.8	73.6	65.7	74.6
September	0.53	61.0	51.6	57.8	59.0
October	0.63	97.4	98.3	76.4	86.4
November	0.66	93.2	96.7	78.0	88.3
December	0.70	87.8	95.7	76.5	86.7
January, 1933	0.66	76.5	94.8	76.2	83.0
February	0.77	75.0	93.9	75.0	80.0
March	0.75	91.0	94.6	74.2	84.7
April	0.87	93.0	96.3	70.7	71.7
May	1.06	91.6	97.9	59.6	61.4
June	1.33	54.5	93.4	34.1	55.0
July	0.98	65.2	75.7	59.4	57.8
August	0.86	78.5	77.5	72.9	77.1
September	0.95	83.7	84.1	74.2	74.9
October	0.85	96.5	96.8	77.5	85.8
November	0.81	93.2	96.4	78.3	84.8
December	0.81	95.3	97.3	69.2	81.2
January, 1934	0.79	88.5	95.2	77.0	83.3
February	0.83	81.3	92.8	78.4	84.7
March	0.85	88.2	94.0	75.4	81.0
April	0.97	92.2	96.2	73.4	78.9
May	1.30	86.3	96.8	47.0	41.0
June	1.37	84.5	94.3	53.9	47.9
July	1.42	92.0	96.4	69.3	69.5
August	1.14	88.2	89.2	75.9	79.0
September	0.99	99.4	99.5	73.4	78.2
October	0.87	88.6	91.0	76.5	81.0
November	0.76	90.7	95.5	77.1	83.3
December	0.76	92.2	96.4	81.6	89.1
January, 1935	0.74	93.2	94.8	79.7	85.0
February	0.77	85.0	90.0	78.2	80.2
March	0.84	95.6	96.9	77.0	80.0
April	0.93	97.1	98.1	74.7	75.3
May	1.02	93.0	95.7	64.1	58.5
June	1.16	19.8	39.8	60.9	55.8
July	1.21	45.2	78.5	57.3	54.8
August	1.11	17.8	22.4	48.3	56.9
Average for 41 months	0.92	83.0	89.1	67.8	70.8

TABLE 5

	LIME, LBS. M.G. PER P.P.M. ALKALINITY REDUCED	SODA ASH, LBS. M.G. PER P.P.M. NON-CARBONATE HARDNESS REMOVED
April, 1932	26.9	11.3
May	21.0	48.0
June	22.2	
July	28.0*	9.9
August	29.3*	9.4
September	42.3*	7.3
October	25.2*	11.0
November	22.1	10.0
December	23.3	9.8
January, 1933	21.5	10.7
February	19.9	10.2
March	19.7	10.0
April	19.2	9.6
May	17.6	9.3
June	17.8	
July	30.6*	10.1
August	29.9*	8.4
September	24.4*	8.6
October	32.4*	8.6
November	20.5	7.3
December	17.9	7.1
January, 1934	20.8	7.3
February	22.9	7.9
March	22.9	8.6
April	19.7	7.7
May	23.1	6.1
June	23.4	7.5
July	21.4	7.9
August	25.5*	8.8
September	26.6*	9.0
October	29.5*	8.9
November	29.9*	8.7
December	26.9*	7.3
January, 1935	23.3	7.5
February	21.5	7.5
March	20.9	8.4
April	21.1	8.2
May	23.6	9.4
June	21.6	8.7
July	24.6	8.6
August	32.8	7.1
Average (27 months)	21.5	
Average (38 months)		8.7
Average (41 months)	24.2	

* Periods of excessively high turbidity and suspended solids.

At various times, especially during the cloudburst seasons, the taste and odor of the raw water were very objectionable, often offensive. Powdered activated carbon, applied ahead of the secondary clarifier, was used with an average dosage of 2 to 3 p.p.m. and proved very effective.

During the period the water system has been in operation, no cases of water borne diseases have in any way been traceable to the water supply nor have any debilities been found which could be attributed to the use of the highly mineralized water during the periods of low river flow and high mineral content.

In a paper[1] presented by Dr. R. O. Schofield, Chief Surgeon, Six Companies, the contracting organization which built Boulder Dam the following excerpt is of interest.

"The question of fluorin has been brought up because during the past few months there has been considerable concern expressed over the high fluorin content of the water that is used for drinking purposes in Boulder City. The statement has been made that the teeth of our children are soft and crumbling, and that there is an interference with normal dentition. From my own examinations of the children who live here, it is not true that the above defects can be shown to exist in any greater proportion in this community than elsewhere."

Table 4 shows the percentage of reduction of turbidity and suspended solids at the pre-treatment clarifier and the reduction of total hardness and non-carbonate hardness at the softening plant.

The chemical consumption is indicated in table 5.

The lime was used as a coagulant at both the river clarifier and the softening plant. This treatment was described in the September 7, 1933 issue, 3: 10, *Engineering News-Record* as follows:

". . . the influent to the presedimentation basin contained 70,530 p.p.m. suspended solids. This infiuent was given a normal dose of lime, and a removal of 38,570 p.p.m. was effected. The treating plant influent, containing 31,000 p.p.m. suspended solids, was dosed with sufficient lime to produce a hydroxide content of more than 250 p.p.m. in the effluent from the primary settling basin. Floc formation in the primary basin was practically negligible, and the overflow contained approximately 19,000 p.p.m. The effluent was given a heavy CO_2 treatment in the primary carbonation basin, with a resultant heavy floc formation of 5.5 feet per hour settling rate."

QUALITY OF WATER AFTER STORAGE

After storage of water in the Boulder Dam reservoir began in February, 1935 the characteristics of the water changed slowly from

[1] California and Western Medicine, 42: 1, January, 1935.

day to day and accordingly treatment was much easier and the results more uniform. When treating the run-of-the-river it was frequently difficult and often impossible to produce a treated water without variations of 25 p.p.m. or more in total hardness from that desired.

A standard for the plant effluent of 100 to 125 p.p.m. during the period from March 1932 to February 1935 was set up. This standard was quite difficult to maintain with the wide variations and sudden changes in the raw water. After storage began and the water changed slowly and approached uniform conditions gradually little difficulty was experienced in maintaining a total hardness in the finished product of 90 p.p.m., with daily variations seldom exceeding 5 p.p.m. In ordinary routine operation methods, after storage began, no difficulty was experienced in producing a plant effluent with a total hardness of 40 p.p.m., of which 28 p.p.m. were carbonate hardness.

With the storage at Boulder Dam it is estimated that the water passed will have a total hardness of about 275 to 300 p.p.m. of which 140 to 160 p.p.m. will be non-carbonate and with a range of probably 50 percent in either direction.

The foregoing is simply an estimate based upon weighted averages for a 5-year period from 1925 to 1930 and for a three and one-half-year period from 1932 to 1935 as determined at Bright Angel, Grand Canyon and at Boulder City. The Bright Angel averages gave a total hardness of 274 p.p.m. of which 139 p.p.m. were non-carbonate and residue on evaporation as 571 p.p.m. These ranged for the five years, for total hardness from 251 to 311 p.p.m., non-carbonate from 121 to 160 p.p.m., residue on evaporation from 509 to 645 p.p.m. For the period of 38 months at Boulder City the weighted averages gave total hardness as 295 p.p.m., non-carbonate hardness as 163 p.p.m. and dissolved solids as 1037 p.p.m. The differences between the results at the two points result from subnormal flow in the river during the 1932–1935 period, also to a slight extent the effect of the flows from the Virgin and Muddy Rivers. By extended computations, using average river flows and estimated discharge at Boulder Dam, it is probable that a much closer estimate could have been arrived at as to the limits of the range of hardness and dissolved solids.

Judging from the results of tests made for chlorides since storage began in the reservoir, it does not appear that the average content of the radicle will exceed to any great extent the weighted average as

obtained from the Boulder City tests prior to storage. This average was found to be 156 p.p.m. The five-year weighted average at Bright Angel was 53 p.p.m. and the average at Boulder City since storage began in February 1935 to August 31, 1935 was 99 p.p.m.

Computations based upon the weighted averages, the hydrated lime and soda ash used, at Boulder City indicate that Colorado River water from the reservoir may be softened to have a yearly average total hardness of 95 p.p.m. and non-carbonate hardness of 48 p.p.m. by using a dosage of 1827.5 pounds of hydrated lime and 1000.5 pounds of soda ash per million gallons of water treated or a dosage of 219 p.p.m. of hydrated lime and 120 p.p.m. of soda ash, the lime and soda ash of a quality which will meet the Federal Specifications for these materials.

Soap losses, based upon results of experiments conducted to determine the wastage of soap by hard water by Hudson, Snyder, Foulk and other investigators, indicate a serious economic waste. Based on the assumptions of the above investigators, the loss per family of five using water of a total hardness 295 p.p.m. would be 133.6 pounds of soap per family of five per year and with soap at an average price of 12 cents per pound, a loss of $16.03. By reducing the total hardness to 95 p.p.m. a saving of 87.6 pounds of soap or $10.51 per family of five per year is effected.

The water supply for Boulder City was operated under the supervision of the writer, as Sanitary Engineer, from March, 1932 to June, 1935, under the general direction of Walker R. Young, Construction Engineer, U. S. Bureau of Reclamation. The designs for the system were made by the Denver office of the Bureau of Reclamation under the direction of L. N. McClellan, Chief Electrical Engineer. All designing work is under the direction of J. L. Savage, Chief Designing Engineer. All engineering and construction work of the Bureau of Reclamation is under the general direction of R. F. Walter, Chief Engineer, whose headquarters are at Denver, Colorado. All activities of the Bureau are under the general direction of Elwood Mead, Commissioner, Washington, D. C.

(*Presented before the California Section Meeting, October 25, 1935.*)

DISCUSSION

TANK PAINTING

C. F. Harris (Division Manager, Detroit Graphite Company, Detroit, Mich.): Painting tanks is a necessary nuisance. If you do not paint, you eventually lose your tank through rust and corrosion. If you do paint, you have to take the tank out of service and hurry through the job so it can go back into productive service. If you get a good job, you do not have to do it as often. If you do not get a good job your maintenance budget is ruined. It seems simple then, that all you have to do is select the paint which will last the longest. No problem there, is there? But what is the best paint? I see 1500 manufacturers stepping forward to claim that distinction. I can even see members of this Association from different points rising to say that the paint they use is undoubtedly best. Something is wrong. They cannot all be right.

Perhaps we're off on the wrong foot. Maybe it isn't paint alone that does the trick. It's a combination of good paint, good preparation of surface and good application. No single supplier or agent can wrap up that combination and deliver it to you with assurance of best results. Good paint on poor surfaces and poor paint on good surfaces are wasteful extravagances. We start from there.

Take the surface first. It must be clean. It must be free from dirt, grease, loose paint film, etc. If it is pitted, all rust must be removed. Whether you need wire brushes, scrapers or even sand blast depends on the severity of the situation. A poorly prepared surface can ruin a paint job as fast as you can apply the paint. Thoroughness in cleaning is vital.

It is obvious of course, that no paint should be applied in damp or foggy weather, or when temperatures are below 40 degrees F. Paint will not dry in cold or damp weather and the painting of water tanks is difficult enough under normal conditions without fighting the weather too.

Whether you apply the paint yourself or contract for labor, there are certain requirements that must be recognized for best results.

1. Paint should be delivered to the job in unopened packages plainly identified with the manufacturers label.

2. Paint should not be stored in open packages. Exposure in open cans is detrimental.
3. Only thinners recommended by the manufacturer should be used, and only in the proportions suggested by him.
4. Do not apply successive coats before preceding coats have thoroughly dried. An attempt to save time by hurrying will cause the paint to skin over and early failure will result.
5. Spot and priming coats should be thoroughly brushed out. This is particularly important at plate laps and around rivet heads.
6. Use good brushes, or if applied by spray, be sure air pressure is thoroughly atomizing the paint.
7. All paint should be thoroughly stirred and boxed just before application.

Local conditions may suggest other precautions which are necessary for long service. Your paint manufacturer can help you materially in this respect if you will ask his advice.

We come now to the purchase of the paint, the last but most important step. Shall we do a real job and forget it for years to come, or save time and initial cost at the expense of long service? There is no middle ground. A good job consists of three coats inside and three coats outside. If the present paint is not too far gone, we can eliminate one coat. Wise maintenance men figure that once a job is properly painted, they can determine through regular inspection when repainting is necessary and in that way get by with one coat and very little cleaning. They are correct. Good paint wears away uniformly and if the work is done before the base coat is exposed to the point of deterioration, you can save expensive cleaning and the cost of one coat. Here again the paint manufacturer can help you if you will let him.

In this discussion we shall cover three coat work for severe conditions and work back from that.

PRIMING COAT

The purpose of the first or priming coat is not to resist weather, or under water exposure. Its function is to create the closest possible bond between the metal and succeeding coats. It is like the concrete foundation for a home or building. The solidity and permanence of the job depend largely on this coat. This primer must have rust inhibitive qualities. It must retard any rust action that might start underneath the film through natural causes. It must in turn be

protected from moisture and weather by paints designed for these purposes.

INTERMEDIATE COAT

There are two good reasons for an intermediate coat. First, the average paint film is $\frac{1}{100}$ of an inch thick. Three coats are only $\frac{3}{300}$ of an inch thick. That added thickness, properly obtained, may mean an extra two or three years service. It costs less to apply while the job is in progress than another coat would cost later on if applied alone. The other reason is that this intermediate coat acts as a stabilizer or balance between the hard drying inhibitive prime coat and the long oil or elastic finish coat. If this blending of coats is not obtained, there is chance for cracking or peeling due to expansion and contraction of metal under temperature changes.

FINAL COAT

When it comes to final coats we have two different problems. The paint that will stand up under submersion in water is a poor weather resisting paint and vice-versa. Neither can do the other's work, any more than an accountant could erect a building. They are both essential, but in their proper spheres.

PAINTING FIRE HYDRANTS

This subject provides a contrast in painting problems that should convince the most skeptical that just applying paint on a surface will not insure satisfaction.

We paint water tanks and structures of that kind for *protection*, whereas we paint fire hydrants for *identification* and *decoration*. When you buy paint you must know whether you want protection or decoration because to get one, you inevitably have to sacrifice part of the other.

In a fire hydrant enamel you want above everything else "color permanence." If your color is bright red you do not want it to change in a short time to pink or maroon. If you use yellow, you do not want white or orange. Permanent colors cannot be obtained at bargain prices. Just as a matter of comparison, you can purchase red dry colors at 5 cents per pound, but the red dry color that should be used in fire hydrant red costs $1.35 per pound. It takes at least $1\frac{1}{2}$ pounds to make a gallon, plus the cost of your vehicle, so you can readily see why permanent colors are expensive. You cannot deter-

mine whether the manufacturer is using the expensive permanent or cheap substitute pigment except by costly analysis so again we go back to buying on faith.

In almost every case hydrants are made from cast iron which does not rust. Nevertheless a base coat is necessary. The high gloss finish enamel does not have sufficient bonding qualities to be used alone. If when new hydrants are installed, a suitable primer is applied and then followed with good enamel, the question of re-priming should never come up except of course where the prime coat is damaged by abrasion, etc.

On old hydrants where proper painting procedure was not followed, and repainting has been required too often because of rapid paint failure, the surfaces should be cleaned down to the iron and repainted the same as new hydrants.

Because different companies use so many different standard shades it is impossible here to lay out a definite recommendation.

We produce all colors, including special color matches and of course the correct primers to go with the different colors. Prices vary depending on the colors desired. No definite formula can be written on what to buy. Tell the manufacturer just what you want and what you want to accomplish and if he is a reputable manufacturer, he will deal squarely with you.

BUYING PAINT

Just a word about buying paint. What do you get when you buy a gallon of paint? The only definite fact is that you get a can containing 231 cubic inches of assembled raw materials. Most paints look alike in the cans. You cannot handle the paint film in advance so you can compare thickness, density, tensile strength, adhesiveness. etc. You can feel, taste or smell articles like bolts, nuts, brushes, brooms, etc. but you buy paint on faith. You do not know whether you make a wise or foolish purchase until the paint has completed its life which may be from 3 to 10 years after you have paid for it. Look well, therefore, into the reputation, experience and integrity of the company you deal with and the salesman who calls on you. How long have they been in business; do they specialize in maintenance materials or is their business chiefly that of selling over the counter product finishes, lacquers, etc. Check up their references as you would an application for a trusted position. If you must buy on faith, and there is no alternative, make sure that your faith is well founded.

J. I. NAIRNE, (Manager of the St. Louis Paint and Varnish Division, Certain-Teed Products Corporation, St. Louis, Mo.): It has been estimated that thousands of tons of iron and steel are destroyed annually by that inevitable force known as corrosion. Before entering into a discussion of the specific problem at hand, it would not be amiss to consider first some of the general reactions that occur during this deteriorating process.

Chemists charged with the responsibility of studying metal protective paints and metal painting problems in general have devoted much time and effort to this problem. Although there has been considerable controversy as to the chemical and physical reactions involved, it has generally been conceded that the essential reaction products directly responsible for this destructive force consist of water, carbon dioxide, acids, and hydrogen peroxide. One or all of these constituents may be found in some of the media coming in contact with the painted surface, or may even be generated in the ordinary type of paint film during the deteriorating process.

For instance, metal priming paints may be considered as pigment vehicle compositions which are subject to chemical and physical changes, thus forming some of the essentials which will promote corrosion during decomposition of the vehicle. In fact, it has been pointed out that linseed oil is an active stimulator of corrosion when applied to iron, particularly if the old film is abraded in the least degree. It may be clearly seen, then, that the problem of preventing corrosion does not merely consist of applying one or more coats of an ordinary paint to the surface subject to corrosion. Comprehensive, scientific studies have enabled us to formulate metal protective paints and primers by selection of the proper pigment vehicle composition which will actually neutralize the acid decomposition products formed during the deteriorating process of the paint film, and thereby establish neutral or basic conditions within the film, which will actually retard and in many cases prevent entirely the reactions responsible for corrosion.

In the painting of water tanks, especially the interiors, these conditions are highly accentuated due to the continual submersion in at least one of these destructive forces, namely, water. It is essential, therefore, that first of all the proper type of paint be selected for the job. The two main requirements consist: first, of the selection of the proper priming paint, and secondly, the selection of a proper finish coat. The selection of the proper finish coat is equally as

important as that of the priming coat, due to the fact that the chief function of the priming coat is to exert the afore-mentioned inhibiting influence on corrosion, and provide a foundation coat for all subsequent coats of paint to be applied. The finish coat of paint serves then as a protector coat for the primer, and has been constructed in such a manner that it will resist all the normal elements coming in contact with the paint film.

A secondary requisite, but also of the utmost importance, consists of the proper preparation of the surface to be painted, coupled with proper application of the paint. Regardless of the quality of the paint applied, highest success in protection cannot be attained if these two factors are not properly executed. It would be penny wise and pound foolish, for instance, to apply a good grade of paint to an improperly prepared surface, or to apply a good paint improperly to a good surface, in that both of these factors play equally important parts in the ultimate protection obtained.

The surface must be free from all dirt, grease, loose paint, and rust. The method selected properly to prepare the surface depends entirely on its condition. In some cases wire-brushing or scraping might do the trick, while in others sand-blasting may be necessary. No hard and fast rule can be laid down in this respect, but each case should be treated individually, depending upon the prevailing circumstances.

After the surface has been properly prepared, we then come to the application. Of the two most popular methods for application, we normally recommend brush application. Care should be exercised to coat thoroughly the rivet heads and seams which can usually be done more efficiently and more thoroughly with a brush than by spraying. All paint should be applied during dry weather and to a dry surface. Painting during wet weather or when temperatures are below 40°F. should be avoided. The paint should be thoroughly stirred before application and directions for thinning followed exactly as prescribed on the label, if any thinning is necessary.

Our normal recommendation for the painting of both the interior and exterior of water tanks consists of the application of three coats of paint, namely, one substantial coat of primer and two substantial coats of finish paint. The first finish coat, or intermediary, is for the purpose of building up sufficient thickness of film. A normal application of paint will result in a film thickness which is equivalent to about the thickness of an ordinary sheet of paper. The reason for this intermediate coat becomes, therefore, quite obvious. These

recommendations, both with regard to the types of paint specified as well as the number of coats to be applied, are not merely theoretical, but have been thoroughly tested in actual practice.

TESTS

What recommendations we have made so far have been general and all reliable paint and varnish manufacturers are in accord with them. However, in the painting of water tanks we have a specific problem, and you are interested in a procedure that has already been demonstrated by perhaps the most comprehensive tested conducted by a non-partisan manufacturer and fabricator of water tanks for the sole purpose of selecting the painting procedure most satisfactory and serviceable under extreme conditions. This test was conducted by the Pittsburgh-Des Moines Steel Company at Ambridge, Pennsylvania during 1931 and 1932. In this test 196 different kinds of paints and other coating materials for the protection of the inside surfaces of steel tanks for the storage of water, were applied to the interior surface of an open-top, one million gallon tank. All of the paints, together with the procedures for application, were furnished by individual manufacturers, made and applied according to their own recommendations. After exposure for a period of 571 days, during which time the tank was kept in service except when it was drained at intervals for the purpose of inspection, the various paints and coating materials were rated by two engineers and the average ratings recorded. At the end of this exposure period, one panel only out of the 196 had an unbiased rating of 100 percent, and with all due modesty, this panel was that finished with the materials and procedure recommended by the Certain-teed Products Corporation. This particular panel was a three coat job, namely, one coat of No. 1525 Chromate Primer, and two coats of S-1777 Gray Water Resisting Paint for the finish coat. For complete technical data on this entire test we have had a reprint made of Circular No. 3304, which was originally issued by the Pittsburgh-Des Moines Steel Company, showing the analysis of the water in the tank and other interesting data. As a result of this test, the Pittsburgh-Des Moines Steel Company started using these products in the Spring of 1932, and, therefore, these products have been in use for practically three and a half years on tanks in all sections of the country. We should like to quote from a recent letter received from them as follows:

"We have used the paint in all sections of the country and undoubtedly there will be instances where it will not last as long as under more favorable conditions, but considering the time we have been using the material we have received fewer complaints than with any other type of paint which we have used for this purpose and we are positive that the material is definitely superior to types of paints commonly used for water tank interiors before the Ambridge, Pennsylvania test.

"The Technical Bulletin #3304 has created a considerable amount of interest among engineers, the bulletin having been reprinted two times. We have had requests for copies of the bulletin from engineers in all parts of this country and from many foreign countries."

(*Presented before the Virginia Section Meeting, November 7, 1935.*)

DAMAGE SUITS FOR MOTTLED ENAMEL FROM PUBLIC WATER SUPPLY AT CHETOPA, KANSAS

SUMMARY BY A. W. BLOHM

(State Department of Health, Baltimore, Md.)

Because of mottled enamel alleged to have been caused by drinking the water supplied by the town of Chetopa, Kansas, the town is now being faced with two suits for damages. One of the suits filed by a girl, seventeen years of age, through her father, claims damages amounting to $25,000. It is claimed that the public water supply has not only caused the loss of the front teeth, but also the certainty of losing the remaining teeth in the very near future. It is further alleged that the weakened structure of the bones throughout the body make it impossible for her to do any strenuous exercising for the balance of her life and thus limits her future activity to only very light work. The second suit of a similar nature was dropped by the plaintiff, it is not definitely known whether it has been dropped permanently or will be reentered.

Chetopa is a town of 1344 population, located in the southeast part of Kansas. Its water supply is obtained from two wells 1200 feet deep, presumably from the Mississippian formation. Water from this formation is thought to be absorbed by the outcrop of limestone in the Ozark Mountains in Oklahoma and Arkansas. The strata dip to the west and north and, at Chetopa, water from these strata is under a partial artesian head, rising to within 60 feet of the surface. Numerous towns in this area obtain their water supplies presumably from the same source. Columbus, Pittsburg, Girard, Frontenac, and other smaller towns have deep wells of about the same depth and obtain a water which is similar in some respects to that of Chetopa, but different in others. There is no evidence, however, that mottled enamel is present in any of these towns. At Columbus, the nearest town and in nearly all ways comparable to Chetopa, no mottled enamel was found in a dental examination of school children, according to the county health officer who made the examination. The present water supply of Chetopa has been in use since 1905.

In 1929 attention was called to the existence of mottled enamel at Chetopa and the belief that the municipal water supply was responsible. Early in 1930 a study was made with the assistance of two dentists who volunteered their services. Ninety school children were found, mostly from rural districts, who had used city water only at school. Eighty-nine percent did not have mottled enamel. The group which had used city water as their sole source of drinking water numbered 198. The examination of this group was presented graphically in THIS JOURNAL, Volume 23, No. 2, page 220. The results of this examination clearly indicated the water supply to be at fault, but the State Board of Health was reluctant to order a change in the supply without being able to state definitely the cause of the condition. It was at first suspected that the trouble was caused by high sodium bicarbonate content, but this hypothesis was upset by the number of places which had similar amounts of sodium bicarbonate and no dental defect.

Following the announcement in 1931 that fluoride had been found as the cause of mottled enamel, an examination of the city water showed the presence of approximately 8 p.p.m. of fluorides. The city was unofficially advised to give warning with regard to the use of the water by children. A statement to the effect that the supply was unfit for consumption by children was accordingly printed on all water bills. A bond election for a new water supply was called for August 2, 1932 but did not meet with popular approval. Following the city's failure to improve the supply the State Board of Health ordered—"such change or changes in the city water supply of Chetopa as may be necessary to eliminate the cause of mottled enamel. . . ." There have been one or two bond elections since, but the electorate have refused to authorize the city to issue bonds. In 1934 the State Board requested the city officials to revise their cost estimate, to call for a special election and for the sake of the children to make a special effort to avoid the bitter factional controversy which previously had defeated the issue.

The law gives the State Board of Health the power to order a municipality to improve its water supply. If, however, this improvement costs more than $1000, then the local governing body must authorize the issuance of bonds at an election called for that purpose.

Due to the continued inaction of the city the State Board of Health passed a resolution June 28, 1935, ordering that the city water supply of Chetopa shall not be made available for the use of children in the

public schools or in any other public building or place. The order has resulted in an effort to reconstruct the wells in order to case off the formation from which fluorides have been obtained. Recasement of the first well has reduced the fluoride content of the supply from 8 to 2.4 p.p.m. and it is believed the recasing of the other well will reduce this quantity still further. A fluoride content not exceeding 1.0 p.p.m. will be acceptable to the State Board of Health.

REPORT OF SECTIONAL COMMITTEE A-21 ON SPECIFICATIONS FOR CAST IRON PIPE, YEAR 1935

TECHNICAL COMMITTEE I ON DIMENSIONS

Sub-Committee 1-A on Barrel of Sand Cast Pipe. At meetings of Sub-Committee 1-A held in New York in January and April, 1935, much progress was made toward agreement on thickness schedules for pipe, both pit cast and special types. Since that date work on this problem has been continued by Mr. F. H. Stephenson, under the direction of Mr. T. H. Wiggin, Chairman of the Sectional Committee, resulting in a report and set of thickness schedules which were sent out in November, 1935. At the end of the year these were still under consideration by the sub-committee. These schedules give thicknesses needed throughout the range encountered in practice, not only for internal water pressures (and water hammer), but also for different conditions of bedding and backfilling and varying external loads from earth cover and trucks.

Sub-Committee 1-B on Bell and Spigot Dimensions of Cast Iron Pipe, Including Lugs and Harnesses. Bulletin 87 of the Engineering Experiment Station of Ohio State University, was prepared by Prof. J. C. Prior, of Ohio State University, Chairman of Sub-Committee 1-B, and issued in January, 1935. This bulletin describes the tests made by Prof. Prior for the Cast Iron Pipe Research Association, the Division of Water of the City of Columbus, Ohio and the Sectional Committee on Specifications for Cast Iron Pipe. The tests were as follows. Pull-out and deflection tests of bell and spigot joints, with lead, Leadite, Hydrotite and cement used as jointing material. Pull-out tests on pipe 6- to 60-inch diameter with internal water pressures up to 500 pounds per square inch. Deflection tests on 20-inch pipe with loads up to 100,000 pounds. Circumferential deformations and behavior of joints given. Tests of strength of Dresser harness restraining a 36-inch bell and spigot joint with internal water pressure up to 300 pounds per square inch.

Sub-Committee 1-C on Pipe Other Than Pit Cast. The work of this committee is now merged with that of Sub-Committee 1-A, mentioned above.

Sub-Committee 1-D on Fittings. After completion of the bursting tests of fittings made for the committee at University of Illinois, and the reports and recommendations on design of fittings prepared under the direction of Mr. Wiggin by Mr. F. H. Stephenson and presented to the committee in 1934, the manufacturing companies (in addition to a series of bursting tests of fittings which they made to supplement those of the committee) launched another series of such tests. These were finished during the year and were under study by the producers in preparation for their presentation to the committee.

Bulletin 20 of the Engineering Experiment Station of Cornell University was issued in September, 1935. This is entitled "Long versus Short Body Fittings for Water Supply" and consists of two parts. Part I, Loss of Head Caused by Bends, Tees and Crosses, by Ernest W. Schoder and Arthur N. Vanderlip. Part II, Economic Comparison, Considering Operating Cost, as Affected by Friction, and Installation Cost, by Allan T. Ricketts and Thomas H. Wiggin. Friction loss tests on 6- and 12-inch cast iron bends, tees and crosses. Tees and crosses tested with four sizes of radii of "fillets" (or the curved portions at intersections of run and branch), viz., 6-inch (A. W. W. A.), 2½-inch (Short Body), 1-inch and sharp corners. Test velocities 3, 6 and 10 feet per second. Various divisions of flow in and out of tees and crosses. The Economic Comparison applies the friction loss values for the different kinds of fittings to a pipe distribution system for both domestic and fire flows and also to a case of higher velocities in a pumping station discharge header.

TECHNICAL COMMITTEE II ON METALLURGY, PROCESSES AND TESTS

Sub-Committee 2-A on Raw Materials and Melting Practice. Work finished.

Sub-Committee 2-B on Metallurgy and Chemistry. Work finished.

Sub-Committee 2-C on Physical Tests and Test Specimens. Revisions were made in the drafts of specifications for test bars and test specimens.

Sub-Committee 2-D on Experience. Work finished.

TECHNICAL COMMITTEE III ON CORROSION AND PROTECTIVE COATINGS

Sub-Committee 3-A on Theory of Corrosion of Cast Iron Pipe. Work finished.

Sub-Committee 3-B on Organic Coatings. The specification for

organic coatings adopted by the sub-committee was approved by Technical Committee 3 in 1934. Further advance was delayed by suggestion of an alternate specification.

Sub-Committee 3-C on Inorganic Coatings. Progress was made toward agreement on the new specification for cement mortar lining, which if adopted will replace the one adopted by the Sectional Committee in 1931 and published in the April, 1932, *Journal.*

Sub-Committee 3-D on Water Corrosion Experience. Work finished.

Sub-Committee 3-E on Soil Corrosion. Work finished.

Sub-Committee 3-F on Hydraulics. Work finished.

T. H. WIGGIN, *Chairman,*
N. F. S. RUSSELL, *Vice-Chairman,*
C. C. SIMPSON, JR., *Secretary,*
A. V. RUGGLES, *Exec. Assistant to Chairman.*

BULLETINS PUBLISHED BY OR IN COOPERATION WITH SECTIONAL COMMITTEE A-21 (OF AMERICAN STANDARDS ASSOCIATION) ON SPECIFICATIONS FOR CAST IRON PIPE

OHIO STATE BULLETIN

Ohio State University Engineering Experiment Station Bulletin No. 87: Investigation of Bell and Spigot Joints in Cast-Iron Water Pipes. Part I, Pull-out Strength; Part II, Bell Strength; Part III, Harness Strength. John C. Prior. Tests made for the Cast Iron Pipe Research Association, the Division of Water of the City of Columbus, Ohio and the Sectional Committee on Specifications for Cast Iron Pipe. Pull-out and deflection tests of bell and spigot joints, with lead, Leadite, Hydrotite and cement used as jointing material. Pull-out tests on pipe 6- to 60-inch diameter with internal water pressures up to 500 pounds per square inch. Deflection tests on 20-inch pipe with loads up to 100,000 pounds. Circumferential deformations and behavior of joints given. Tests of strength of Dresser harness restraining a 36-inch bell and spigot joint with internal water pressure up to 300 pounds per square inch. Bibliography. Appendices on harness designs. 57 pp. illustrated. 50 cents, from Ohio State University, Columbus, Ohio.

CORNELL BULLETIN

Cornell University Engineering Experiment Station Bulletin No. 20: Long versus Short Body Fittings for Water Supply. Part I, Loss of Head Caused by Bends, Tees and Crosses. Ernest W. Schoder and Arthur N. Vanderlip. Part II, Economic Comparison, Considering Operating Cost, as Affected by Friction, and Installation Cost. Allan T. Ricketts and Thomas H. Wiggin. Friction loss tests on 6- and 12-inch cast iron bends, tees and crosses. Tees and crosses tested with four sizes of radii of "fillets" (or the curved portions at intersections of run and branch), viz., 6-inch (A. W. W. A.), 2½-inch (Short Body), 1-inch and sharp corners. Test velocities 3, 6 and 10 feet per second. Various divisions of flow in and out of tees and crosses. The Economic Comparison applies the friction loss values

for the different kinds of fittings to a pipe distribution system for both domestic and fire flows and also to a case of higher velocities in a pumping station discharge header. 102 pp. illustrated. $1.25, from Director, Engineering Experiment Station, Cornell University, Ithaca, N. Y.

COLUMBIA BULLETIN

Report of Tests to Determine the Shearing Strength of Steel Anchor Clips Bronze Welded to Cast Iron Pipe. Part I, Introduction, A. V. Ruggles; Part II, Report on Tests, W. J. Krefeld; Part III, Memorandum on the Tests, L. P. Wood. Tie rods across bell and spigot joints in cast iron pipe lines are sometimes used at bends or where pressures are high and in bad ground, and where lugs or shoulders have not been cast on the pipe in advance the use of steel clips welded to the pipe in the field has been suggested by T. H. Wiggin, chairman of the Sectional Committee. These tests were made to determine the holding strength of such clips. 18 pp. illustrated. 25 cents, from American Water Works Association, New York.

LIST OF SECTION PAPERS

Missouri Valley Section

Des Moines, Ia., November 6–8, 1935

Round Table Discussion:

What financial assistance can be obtained from P.W.A. and W.P.A. for improvements in water works plants and systems?

Discussion led by P. F. Hopkins and A. E. Michel

Symposium on Fundamentals of Water Works Operation:

Relation of the State Department of Health.....Paul J. Houser

Functions of the State Water Laboratory.....Jack J. Hinman, Jr.

Water Softening.....W. E. Galligan

The Des Moines Water Works.....C. B. Burdick

Present Day Water Problems.....H. E. Jordan

The Sale of Water.....C. M. Dailey

Faulty Plumbing Conditions in St. Louis.....W. Scott Johnson

Some Basic Considerations in the Design of Small Impounding Reservoirs in the Middle West

Earle L. Waterman, F. T. Mavis and Edward Soucek

The Economics of Water Softening.....C. M. Stanley

Zeolites, Mining, Processing and Uses in Municipalities.....W. H. Mitchell

The Removal of Iron from Public Water Supplies.....M. J. Shoemaker

Iron Removal and Softening Plant at Indianola, Ia.

Jack J. Hinman, Jr. and Lafayette Higgins, Jr.

Diverse Applications of Activated Carbon.....J. P. Harris and W. A. Welch

New Jersey Section

Trenton, N. J., January 29, 1936

The Relation of Geology to Ground Water Supply in New Jersey

Meredith E. Johnson

Quantitative Investigations of Some New Jersey Ground Water Problems

Henry C. Barksdale

Superintendents' Forum, including a discussion of a number of questions of general interest. Pertinent questions may be introduced by any person in the meeting.

New York Section

Oswego, N. Y., March 26–27, 1936

Improvements and Additions Under TERA, Oswego Water System

W. A. McCaffrey

New Water Works Operating Practices Observed in the Field...F. E. Stuart

Reconditioning Old Water Mains.....Alfred Anderson
Superintendent's Round Table Discussion.....Led by J. Walter Ackerman

1. The prevalence and method of control of algae in reservoirs.
2. The operation of chlorination equipment and the orthotolidine test for residual chlorine.
3. Taste and odor control.
4. Prevalence of red water trouble and methods of preventing corrosion of distribution systems.
5. Filter washing practice with special reference to prevention of mud balls, clogged areas and cracks in the sand beds.
6. Unusual coagulation experiences.
7. The prevalence of iron and manganese in water supplies and methods of removal.

Economies Effected by Constructive Planning.....Edgar K. Wilson
Aim and Purpose of WPA and the Aid Water Works Officials can Render with WPA.....Arthur H. Myers
Recent Progress in the Control of Chlorination.....Charles R. Cox

Canadian Section

Hamilton, Ont., April 1–3, 1936

Reforestation and Water Resources.....A. H. Richardson and S. P. Adams
Some Causes of Water Quality Deterioration in Distribution Systems
Norman J. Howard
Water Works Problems of the Small Municipality
D. H. Fleming, W. D. Stalker and W. G. Breen
A Pitometer Water Waste Survey in Lachine, Que.....Robert Dorion
Anthracite Coal as a Filter Medium.....H. G. Turner
Symposium
Swimming Pools and Water Supply:
Construction features.....E. H. Darling
Operation.....R. H. Heath
Winnipeg Pools.....W. M. Scott
Development of Sulphur Compounds for Jointing Materials..C. R. Payne
Corrosion Problems in Water Works Systems
J. G. Dundan and W. E. Patterson

Indiana Section

Lafayette, Ind., April 7–9, 1936

April 7: School for Water Plant Superintendents, sponsored by Purdue University and Indiana Section, A. W. W. A.
April 8 and 9: General Sessions

April 7

What is a Centrifugal Pump—How Does it Operate?.....F. W. Greve
Some Interesting Facts in Reference to Meter Construction and Operation
F. A. Schaefer

Loss of Revenue Due to Over-sizing of Meters.....Round Table Discussion
Location Records for Mains and Services.....P. C. Gale
The Value of Standards of Practice.....L. S. Finch
Practical Chlorine Handling.....E. F. Kinney
Troubles During Sub-Zero Weather.....Round Table Discussion

April 8

Conserving Our National Water Resources.....Frank R. Shaw
Eliminating Cross Connections.....F. M. Dawson
Water Supply, Public Health and Politics.....H. E. Jordan
Collecting the Money with the Minimum of Friction
A symposium by C. W. Goris, M. F. Gustin, Robert O. Bonner
Herman J. Kennelly and W. S. Hartman
The Value of Elevated Water Storage.....Charles Brossman
Efficiency in Water Plant Pumping Station Operation.....H. G. Coughlen
The Responsibility of the Water Plant Superintendent....Frank A. Barbour
Peace of Mind—One of the Dividends from Good Service.....W. W. Brush

April 9

Better Fire Protection for the Smaller Communities.....Clarence Goldsmith
Cutting Our Fire Losses Through Systematic Inspections, Including the Inspection of All Water and Fire Department Equipment
Richard E. Vernor
Valve Inspection and Maintenance.....A. J. Meyer
Training for Efficient Fire Service.....Clem Smith
Publicizing the Utility.....Miller Hamilton
Motion Picture—"Water Colors"
Courtesy and Appreciation.....Arthur C. Shea
My Job At the Contract Window.....Miss Nelle Coleman
Television Demonstration.....Through courtesy of Prof. C. F. Harding

Fifth Short Course in Water Treatment and Tenth Annual Meeting of Florida Section

Tampa, Fla., March 31, April 1-2, 1936

Problems in the Design of Distribution Systems.....T. M. Lowe
Discussion.....W. N. Jones
Phases of Fire Protection of Interest to Water Works Men.....L. C. Sledge
The Methods of Treatment Employed in the Tampa Water Purification Plant
J. E. Lyles
Effect of Cross-Florida Ship Canal Upon the Underground Water Reserves
Sidney W. Paige
Discussion.....Malcolm Pirnie
Discussion.....Herman Gunter
The Mechanics of Mixing and Settling in Water Treatment....J. M. Kahn
Discussion.....E. L. Filby
Physiological Effects of Mineral Salts Present in Natural Waters
C. B. Pollard

Round Table on Water Works Problems
Rebuilding of Filters at West Palm Beach—Discussion and Films
J. R. Tanner and Keith R. Chinn
Problems in the Sterilization of Water with Ammonia and Chlorine
L. W. Culter, J. R. Hoy, J. E. Lyles
Chloramine Treatment for Control of Iron Bacteria.....Keith R. Chinn
Control of Tastes and Odors.....A. S. Behrman, F. E. Stuart
Laboratory Control of Water Purification Processes.....A. P. Black
The Servicing of Meters.....T. M. Lowe, F. W. Lane, W. N. Jones
Underground Corrosion.....J. T. MacKenzie
Discussion.....A. P. Black
Recent Advances in Sewage Treatment.....G. F. Catlett

Illinois Section

Evanston, Ill., April 10–11, 1936

The Educational Situation in Water Works Engineering..Prof. H. E. Babbitt
Discussion by.....W. W. DeBerard
Recent Improvements and Extensions in the Evanston Water System
H. R. Frye
Discussion by.....D. H. Maxwell
The Relative Importance of the Meter Division to the Water Department
LaVerne Trentlage
The Water Works Superintendent's Place in Swimming Pool Operation
C. W. Klassen
Discussion by.....C. H. Spaulding
Public Works Administration Water Projects in Illinois.....Carl H. Bauer
Relation Between Sewage Disposal and Water Supply Protection for Cities Bordering on Lake Michigan.....R. T. Reilly
Operating Records.....C. M. Roos
Discussion by.....H. M. Ely
Symposium on Cold Weather Troubles
An Unprecedented Period of Low Temperatures—Its Effect on the Chicago Water System.....Loran D. Gayton
A Review of Thawing Service Pipes.....Frank C. Amsbary, Jr.
General Discussion
Problems of the Ordinary Superintendent of Water.....Frank J. Broz
Discussion by.....J. C. McNicol
A Comparison of Odor Elimination Treatments.....Oscar Gullans
Discussion by.....G. B. Prindle
Factors Affecting Corrosion in Natural Waters.....Dr. A. M. Buswell
Discussion by.....John Baylis
Fairbury Softening Plant.....J. J. Woltman
Gravel Packed Wells.....H. L. White
Discussion by.....W. D. Gerber
Sub-surface Filtration at Kenilworth, Illinois.....C. C. Ley

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the journal.

Effect of Cyanide on Black Hills Trout. ANDREW KARSTEN. Black Hills Eng., *22*: 145–74, 1934. From Chem. Abst., **28**: 5562, September 10, 1934. If, in stream used for disposal of cyanamide-cyanide effluent, trout are found dying lower down than usual after severe winter, condition may be attributed to formation of cyanide cryohydrate. Cyanide lost daily during entire cold-weather period may collect in this form and then, with approach of high temperature, pass downstream as unit discharge in concentration sufficient to kill trout for many miles. Cyanide concentrations over 1 p.p.m. are certain to kill all trout within 20 minutes and concentration of 50×10^{-9} in about 120 hours. Concentration of 20×10^{-9} was found non-lethal in 650 hours and such concentration is considered as maximum that stream may contain as far as usual species of trout are concerned. Trout that have been subjected to cyanide to such extent as to be practically lifeless can be revived in fresh water without apparent serious after-effects. When trout are found dying with actions typical of lack of air, and with gills colored brilliant red, it may be taken as evidence that cyanide is cause. Cyanide in stream does not affect oxygen content because atmospheric oxygen maintains solubility equilibrium by furnishing oxygen at rate far greater than that of its removal due to formation of cyanate. Cyanide concentrations lower than those detectable by usual tests may be detrimental to trout. Neither acids, ferrous sulfate, nor potassium permanganate, can be used to destroy cyanide to point at which trout are no longer affected; excess acid or permanganate may be detrimental and must be destroyed before reaching stream. These compounds can, however, be used for reducing stream to effluent ratio, thus making possible use of streams which could not otherwise be employed for disposal of cyanide without harmful action on trout.—*R. E. Thompson.*

Studies in the Formation of Floc by Aluminum Sulfate and Iron Coagulants. EDWARD BARTOW. Okla. A. & M. Coll., Eng. Expt. Sta., Pub. No. **22**: 15, 16, 1934; cf. C. A., **27**: 4327, 4607. From Chem. Abst., **28**: 5907, September 20, 1934.—*R. E. Thompson.*

Preparation of Distilled Water. A. A. GUNTZ. Chimie and industrie, Special No., 238–43, April, 1934. From Chem. Abst., **28**: 5907, September 20, 1934. Distilled water having resistivity of 10^6, or more, ohms per centimeter,

which is better than ordinary doubly distilled water, can be obtained in single operation, without rejection of head and tail fractions of distillate, by distilling in presence of 2 to 4 grams barium hydroxide or 1 to 2 grams sodium hydroxide, 1 or 2 grams potassium persulfate, 10, 5, and 5 milligrams of copper, cobalt, and nickel sulfates, respectively, per liter, and providing glass-wool filter in neck of flask, small electric heating unit being provided just under filter to superheat steam to 110–20° and prevent condensation in filter. Such apparatus will be placed on market shortly.—*R. E. Thompson.*

The Examination of Filtered Swimming-Bath Water. THOS. E. MOGG. Munic. Eng., **93**: 606–8, 1934. From Chem. Abst., **28**: 5562, September 10, 1934. Standardization of methods is urged. Differences in sampling may lead to widely different results. Nitrite indicates incomplete oxidation, or nitrification, or organic matter and presence of even a trace should be regarded with deep suspicion. In new baths, nitrite may be due to reducing agent in brickwork, and may disappear after a time with effective filtration and chlorination. Albuminoid ammonia is indicative of extent of urinary pollution. Measurement of oxygen absorbed is of some value in determining chemical purity; iron, nitrate, and sulfide interfere and must be allowed for.—*R. E. Thompson.*

Determination of Traces of Dissolved Oxygen by the Winkler Method. M. C. SCHWARTZ and W. B. GURNEY. Proc. Am. Soc. Testing Materials, Preprint No. 90: 17 pp., 1934. From Chem. Abst., **28**: 5778, September 20, 1934. In studying power plant deaerator, original WINKLER method was found unsatisfactory. By adding a little standard potassium biniodate solution after usual reagents, known amount of iodine is introduced and then by titrating with thiosulfate and comparing with blank run, better values can be obtained. With this procedure it is not necessary to keep temperature at 21°, or lower, and kind of starch used has little, if any, effect on result. Bibliography appended.—*R. E. Thompson.*

Effect of Water and Steam on the Fabric of Steam Boilers. W. CHRISTMANN. Stahl u. Eisen, **53**: 1353–7, 1933. From Chem. Abst., **28**: 5908, September 20, 1934. Under high-temperature conditions corrosion can be avoided only by maintaining in feed water content of not less than 400 p.p.m. sodium hydroxide, or contents of 20 p.p.m. P_2O_5 and from 100 to 400 p.p.m. sodium hydroxide. Practical upper limit of use of sodium carbonate to prevent calcium sulfate scale is pressure of 15 kilograms per square centimeter. Phosphate can be used at higher pressures, but some calcium sulfate scale is usually found in parts at highest temperature. Instances are recorded of liberation of hydrogen sulfide by reduction of such scale *in situ*, with consequent corrosion.—*R. E. Thompson.*

Softening Water with Hydrogen-Permutite. YU. M. KOSTRIKIN and F. E. PROKHOROV. Trans. Thermo-Tech. Inst. (Moscow), **1934**, 41–4. From Chem. Abst., **28**: 5908, September 20, 1934. Disadvantage of permutite treatment, high alkalinity, can be reduced by replacing sodium ion with hydrogen ion.

Use of 0.05 normal hydrochloric acid with permutite is illustrated and a few examples of treating hard boiler feed water are given.—*R. E. Thompson.*

Construction of Inexpensive Incubators for Water and Sewage Work. J. T. GRIMSLEY. Okla. A. & M. Coll., Eng. Expt. Sta., Pub. No. **22**: 10–13, 1934. From Chem. Abst., **28**: 5909, September 20, 1934. Easily constructed reliable and rugged incubator described.—*R. E. Thompson.*

Tendencies in Standards of River and Lake Cleanliness. H. W. STREETER. Sewage Works J., **6**: 721–33, 1934. From Chem. Abst., **28**: 5911, September 20, 1934. Older standards based on fixed dilution ratios are being superseded by more definite specifications of certain indicators of relative cleanliness such as bacterial content, dissolved oxygen, oxygen demand, and known toxic chemical substances. Where public health is involved, limiting standards of bacterial quality are becoming of primary importance, though in some cases limitation of chemically toxic substances is of equal significance. Where health is not involved, minimum dissolved oxygen standard appears to be most simple and readily applied one for general application, though there is distinct trend toward "oxygen balance" criteria.—*R. E. Thompson.*

The Theory of the Action of Pure Waters on Cements. HENRI LAFUMA. Chimie and industrie, Special No., 719–21, April, 1934. From Chem. Abst., **28**: 5952, September 20, 1934. Dissolving action of water would ultimately bring about total decomposition of hydraulic mortars, if carbonation, which takes place simultaneously, did not afford protection. Efficiency of carbonation as protection for mortars is generally admitted unrestrictedly. Contrary to what takes place in carbonation by calcium bicarbonate, carbonation by air, or by pure waters (which always contain some free carbon dioxide), is not always effective. Efficiency of carbonation is greater according as it affects least soluble and least rapidly hydrolyzable calcareous constituents (aluminates and silicates). This explains why some cements resist action of pure waters better than others.—*R. E. Thompson.*

The Chemistry of Natural Waters. CARL S. SCOFIELD. Trans. Am. Geophys. Union, **1933**, 389–92. From Chem. Abst., **28**: 6217, October 10, 1934. Author reports as chairman of committee and discusses (1) chemical composition of subsurface waters in relation to geological environment; (2) composition in relation to corrosion of ferrous and concrete structures; (3) occurrence of radioactive and rare elements in spring waters; (4) composition in relation to base exchange in geological structures and in soils; (5) composition in relation to hydrographic problems; and (6) quality of water supplies for various purposes.—*R. E. Thompson.*

The Determination of Aluminum in Mineral Waters. VITTORIO GAZZI. Ann. chim. applicata, **24**: 226–9, 1934. From Chem. Abst., **28**: 6219, October 10, 1934. Four samples of mineral waters in which up to 2.2 p.p.m. aluminum had been found by chemical methods, showed on spectrographic examination

about $\frac{1}{1000}$ part of amounts so found. Spectrographic analysis should always accompany chemical analysis of mineral waters.—*R. E. Thompson.*

Determination of the pH Value in Slightly Buffered Solutions. HALVARD LIANDER. Iva, 1934, 57–67. From Chem. Abst., 28: 6049, October 10, 1934. Calculation of pH of unpurified water from content of bicarbonate and carbon dioxide is outlined (cf. C. A., 22: 4316). Principles and uses of electrometric and colorimetric methods of determination are described in detail, with particular reference to waters that are to be subjected to purification. Quinhydrone electrode is considered unsuitable for unbuffered solutions in neighborhood of neutral point. Errors may amount to from 0.1 to 1.0. Glass electrode gives best results, but calibration from time to time is recommended, because of slowly developing asymmetric potential. Most serious source of error in colorimetric determinations is frequent slight buffer action of water, which makes approximately correct measurements impossible unless special precautions are taken. Addition of indicator, which in itself is weak acid or base, changes pH according to pH of indicator solution, amount added, and buffer action of water. Incorrect choice of indicator may cause errors of as much as 1 unit, or more. Opinion that errors can be avoided by use of exactly neutral indicator solutions is erroneous. Most important factor to be observed is pH of indicator solution, which should be as close as possible to that of solution to be measured (cf. C. A., 24: 1567, and also 5: 3835; 7: 2407; 17: 669; 23: 2327; 27: 4155; 28: 1225).—*R. E. Thompson.*

Experimental Investigation on the Bactericidal Oligodynamic Action of Silver. L. SCHIOPPA. Ann. igiene, 43: 571–84, 1933; Chimie & industrie, 31: 1335. From Chem. Abst., 28: 6169, October 10, 1934. Oligodynamic activity of silver is unaffected by hardness of water or by presence of iron and manganese; is decreased slightly by hydrogen sulfide; increases with rise in temperature; is apparently not definitely influenced by number of bacteria, within certain limits; and is but slightly affected by increase in surface of silver.—*R. E. Thompson.*

Effect of Nitric Acid on the Determination of Iron with Permanganate. D. TOTOIESCU. Z. anal. Chem., 96: 183–8, 1934. From Chem. Abst., 28: 2642, May 10, 1934. Further evidence is furnished that if solution containing small quantities of nitric acid is reduced with zinc and titrated with permanganate, results for iron are too high. Nitric acid is reduced for most part to hydroxylamine.—*R. E. Thompson.*

Determination of Fluorine. M. FROMMES. Z. anal. Chem., 96: 211–23, 1934. From Chem. Abst., 28: 2643, May 10, 1934. Review of about 40 recent papers.—*R. E. Thompson.*

The Colorimetric Determination of Traces of Fluorine. L. SZEGÖ and B. CASSONI. Giorn. chim. ind. applicata, 15: 599–602, 1933. From Chem. Abst., 28: 2643, May 10, 1934. In determination according to STEIGER (C. A., 2: 1104), volatilization of SiF_4 is incomplete in presence of large amounts of colloidal silica, whereas, with Na_2SiF_6, it is complete.—*R. E. Thompson.*

Hypochlorite Determinations. F. K. Revva and V. V. Illarionov. J. Applied Chem. (U. S. S. R.), **6**: 568–70, 1933. From Chem. Abst., **28**: 2644, May 10, 1934. Comparative study was made of bromate and permanganate methods. Both give good results. Hydrochloric acid is better than sulfuric acid for acidifying solution.—*R. E. Thompson.*

Electrolytic Corrosion in a Hospital. Wilhelm Franckenstein. Gas- u. Wasserfach, **76**: 934–6, 1933. From Chem. Abst., **28**: 2662, May 10, 1934. Corrosion of water lines, etc., was found to be due to defective grounds on 3-wire direct current system within building and was remedied by suitable independent ground.—*R. E. Thompson.*

Soil Corrosion: Studies 1932. Rate of Loss of Weight and Pitting of Ferrous and Non-ferrous Specimens and Metallic Protective Coatings. K. H. Logan and R. H. Taylor. Bur. Standards J. Research, **12**: 119–45, 1934. Research Paper No. 638. From Chem. Abst., **28**: 2661, May 10, 1934. Data obtained from specimens removed in 1932 are given. In most soils, rate of corrosion decreases apparently with time, because either of more stable trench conditions, or of formation of corrosion products, tending ultimately toward fixed rate. Prediction of rate of corrosion, based upon soil types established by United States Department of Agriculture, seems possible. Type of soil, rather than variety of ferrous metal, is usually controlling factor; but in certain soils, proper choice of material assumes great importance. Copper and alloys high in copper corrode less rapidly than most ferrous materials in soils investigated. Zinc coating weighing 1 ounce per square foot should extend life of coated material at least 6 years in very corrosive soils and much longer under more favorable conditions.—*R. E. Thompson.*

A Practical Method of Electrical Protection for Pipe Lines Against Soil Corrosion. Starr Thayer. Natural Gas, **14**: 11, 6–12, 1933; Proc. Am. Petroleum Inst. 14th Ann. Meeting Sect. IV, 143–52. From Chem. Abst., **28**: 2662, May 10, 1934. Experiments in laboratory and field showed that hot application of coal-tar enamel and maintenance of potential difference of 0.3 volt is sufficient to stop corrosion. Experiments with grease-coated lines showed that cost of protecting them electrically is at least 9 times as much as that for enameled lines, which are completely protected. Any highly electrically-resistant coating is adaptable to this type of permanent protection.—*R. E. Thompson.*

The Theories of Corrosion. V. O. A. Knight. Mineral Industries, Penna. State Coll. 3, No. 5, 2, 4, 1934; cf. C. A., **28**: 1647. From Chem. Abst., **28**: 2660, May 10, 1934. Soil corrosion is considered.—*R. E. Thompson.*

Corrosion Troubles with Cast Iron Pipes Laid in Gronigen Soil; Causes and Methods of Combating. C. M. Wichers. Wasser, **7**: 117–32, 1933. From Chem. Abst., **28**: 2662, May 10, 1934. From study of mains and chemical examinations of earth around pipes, author concludes that corrosion is independent of type of iron and is favored by: (1) loosely packed soil immediately around pipes through which air and water pass readily; (2) low pH; (3) pres-

ence of hydrogen sulfide; (4) absence of calcium carbonate; and (5) presence of sulfate. Reduction of sulfate (by bacterial action) is not in itself regarded as cause of corrosion; but entrance of oxygen makes this condition dangerous. In case of soil containing ferrous sulfide where entrance of oxygen is possible, pH is no measure of danger of corrosion, as ferrous sulfate formed would have acid reaction and basic ferric salts an alkaline reaction. Corrosion may be prevented by keeping mains dry, as by use of protective coating. Cheap means of decreasing corrosion is packing pipes when laid with well compacted layer of clay or loam, 10 centimeters thick. Lime should be added if clay or loam is in itself corrosive. In appended discussion, use of protective coatings, particularly of bituminous type, is considered.—*R. E. Thompson.*

Protection of Metallic Pipes Buried in Soil Against Electrolytic Corrosion, Especially from Stray Earth Currents. F. BESIG. Gas- u. Wasserfach, **77**: 37-42, 1934; cf. C. A., **27**: 2411. From Chem. Abst. **28**: 2662, May 10, 1934. Potential or current measurements are necessary to determine definitely whether given case of corrosion is electrolytic or chemical. Pipe coatings are perhaps most important protective measure. Various types of coating are mentioned. While it is desirable to remedy stray currents at their source, in some cases insulating couplings may be used, where drop across coupling does not exceed 0.1 volt; but this must be checked frequently. Five types of insulating couplings are illustrated and described. Such couplings should not be used in low-resistance soil. Electrical drainage methods sometimes give good results, but care must be taken in their insulation and they must be continuously supervised while in use.—*R. E. Thompson.*

Behavior of Steel Pipe under Strongly Corrosive Conditions. F. EISENSTECKEN and E. GEROLD. Gas- u. Wasserfach, **76**: 934, 1934; cf. C. A., **27**: 5042. From Chem. Abst., **28**: 2662, May 10, 1934. Electrolytic corrosion is independent of pipe material and can be minimized by use of insulating coatings, insulating couplings, and electrical drainage systems. Potential difference across insulating couplings should not exceed 0.1 volt. Periodic tests should be made on both insulating couplings and drainage systems.—*R. E. Thompson.*

The Effect of Water on Iron Pipes. JOHN R. BAYLIS. Proc. Am. Soc. Munic. Engrs., **39**: 177-83, 1933. From Chem. Abst., **28**: 2663, May 10, 1934. Brief review of theory of corrosion and of formation and building up of tubercles and of their destruction.—*R. E. Thompson.*

Nature of the Reaction of Escherichia Coli on Endo's Medium. L. A. MARGOLENA and P. A. HANSEN. Stain Tech., **8**: 131-8, 1933. From Chem. Abst., **28**: 2744, May 10, 1934. Typical reaction is caused by acetaldehyde.—*R. E. Thompson.*

Purification of Water. A Practical Method of Purifying Water for an Army on the March. M. GARRET. Tribuna farm., **2**: 56-8, 1934; cf. C. A., **26**: 1997, 4118. From Chem. Abst., **28**: 2813, May 10, 1934. Four light compact canvas

filters will supply 25 men with 2.4 liters per day for 10 days. Filter consists of layer of potassium permanganate, talc, and alum and one of sodium thiosulfate, talc, and sodium carbonate, separated and covered with pressed cotton batting and flannel.—*R. E. Thompson.*

Lowering the Residual Hardness of the Water During Filtration. Yu. M. Kostrikin. Izvestiya Teplotekh. Inst., **1933,** 10, 44–5. From Chem. Abst., **28:** 2813, May 10, 1934. Lime treatment prior to permutite softening produces water more suitable for boiler feed than permutite treatment alone.—*R. E. Thompson.*

Determination of the Hardness of Water with the Potassium Salts of Acids from Cottonseed Oil. E. A. Nikiforov. Izvestiya Teplotekh. Inst., **1933,** 10, 42–4. From Chem. Abst., **28:** 2813, May 10, 1934. Natural cottonseed oil contains 22.26, 26.90, and 46.50 percent, respectively, of the glycerides of palmitic, oleic, and linoleic acids, together with 1.85 percent unsaponifiable matter. Oil is saponified on water bath with concentrated potassium hydroxide solution; lumps formed are dissolved in large volume distilled water and solution filtered; soap thus obtained is split with hydrochloric acid and excess acid removed by washing with warm water. Decinormal solution of acids, corresponding to 0.28° (German degrees), is then prepared in manner similar to Blacher, Grunberg, and Kissa solutions (cf. C. A., **7:** 1938). Determination, carried out by Blacher method, is described.—*R. E. Thompson.*

Influence of the Marble Filter on the Residual Hardness of Water Softened by the Soda-Lime Method. N. E. Kushlyanskiĭ. Izvestigya Teplotekh. Inst., **1933,** 10, 45–7. From Chem. Abst., **28:** 2813, May 10, 1934. Procedure is reported in detail, results tabulated, and following conclusions derived: (1) filtration through crushed marble or other stone lowers residual hardness of water softened by soda-lime method, or by preliminary lime treatment; (2) reduction of hardness is in direct relation to temperature of water and inversely proportional ts filtration rate; and (3) crushed marble is 50 percent more efficient than quartz-sand filter.—*R. E. Thompson.*

The Harmful Effect of Ammonia Liquor and Still Waste of Coke Plants on the Fish in Public Waters. G. A. Brender à Brandis and W. Keeman. Het Gas, **54:** 2–13, 1934. From Chem. Abst. **28:** 2819, May 10, 1934. Review. Data are given on composition and quantity of ammonia liquor and still waste from various types of plants and on toxicity of various constituents. Treatment of waste discussed and extensive references listed.—*R. E. Thompson.*

Observations on Changes in Numbers of Bacteria in Polluted Water. C. T. Butterfield. Sewage Works J., **5:** 601–22, 1933. From Chem. Abst., **28:** 2818, May 10, 1934. Average results of intensive observations made on bacterial changes occurring in 166 samples of polluted water collected from 4 sources and held at 10°, 20°, and 37° indicate that at all 3 temperatures bacteria increased to maximum and then decreased. Rate of increase varied with

temperature, being most rapid at higher temperatures. Following factors were studied: nature of containing vessel, size of sample, exposure to light, presence or absence of air surface, and occasional agitation. Centrifuging, or filtering, very materially increased tendency of bacteria to increase on storage. As waters in polluted stream, after maximum bacterial concentration has been reached, tend to consistent and rapid decrease, results show that the more extensive the interference with normal conditions, the greater the increase in bacterial numbers.—*R. E. Thompson.*

To What Extent Can the Relation Between Permanganate Consumption and Chlorine Number Be Taken to Indicate Pollution of Waters? ALFONS KAESS. Gesundh.-Ing., **57**: 30–2, 41–5, 1934. From Chem. Abst., **28**: 2818, May 10, 1934. Investigations were carried out on dilute sewage, drinking (ground) water, and river water. Permanganate consumption was determined by method of KUBEL-TIEMANN and chlorine number by FROBOESE'S modification (cf. C. A., **15**: 913) of method of ELMANOWITCH and ZALESKI except that reaction mixture was heated 30 minutes in rapidly boiling water bath. Data presented in tables and graphs indicate that ratio (permanganate consumption)/(chlorine number) cannot be taken as index of fecal pollution and that this value shows no definite relation to coli titer. In cases where pollution is slight, as in drinking water, organic matter is readily oxidized, although optimum conditions of temperature, pH, etc., may favor multiplication of *B. coli*. Permanganate consumption and chlorine number were parallel in samples of same river water taken on various days.—*R. E. Thompson.*

Effect of Sunlight on Dissolved Oxygen in the White River. C. K. CALVERT. Sewage Works J., **5**: 685–94, 1933. From Chem. Abst. **28**: 2819, May 10, 1934. Although knowledge of dissolved oxygen in polluted stream is of value in determining condition of water, experiments made on samples of polluted water from White River, Indiana, indicate that conditions of temperature and of light and darkness affect these values and therefore they must be used with care. By comparing chloride concentrations with dissolved oxygen values under varying conditions, conclusion was reached that organic load in White River below Indianapolis is frequently such that while in bright sunlight biologic activity of water is able to maintain considerable oxygen concentration, yet in absence of sunlight oxygen content may be zero.—*R. E. Thompson.*

Reactions of Nessler's Solution. M. L. NICHOLS and C. O. WILLITS. J. Am. Chem. Soc., **56**: 769–74, 1934. From Chem. Abst. **28**: 3023, May 20, 1934. Color developed in NESSLER'S solution by ammonia is due to negatively charged colloidal particles of $NH_2Hg_2I_3$. Composition was substantiated both indirectly and by analysis. With solution 3 normal in sodium hydroxide, range of permanent color is increased by addition of stabilized alkaline ash-free gelatin as protective colloid.—*R. E. Thompson.*

Chemical Behaviour of Eternite (Asbestos-Cement) Pipes. H. E. RICHTER. Gas- u. Wasserfach, **77**: 119–22, 1934. From Chem. Abst., **28**: 3155, May 20,

1934. Water allowed to stand for some time in new Eternite pipes becomes unusable. In presence of aggressive carbon dioxide, appreciable amount of calcium bicarbonate may be formed. In absence of aggressive carbon dioxide, calcium carbonate coating may be formed by adding lime, and when coating is once formed no change occurs in water allowed to stand in pipe unless aggressive carbon dioxide is present. Iron and manganese bicarbonates favor formation of such coatings. In absence of these compounds, and with aggressive carbon dioxide present, complete destruction of pipe may result in time.—*R. E. Thompson.*

Organic Substances and the Acid Corrosion of Iron. HANNS PIRIK and WILHELM WENZEL. Korrosion u. Metallschutz, **10**: 29–38, 1934. From Chem. Abst., **28**: 3043, May 20, 1934. Detailed classification and listing of large number of inhibitors, with numerous references and list of patents. Relation exists between inhibiting action of organic substances and their chemical constitution. Active atomic groups, molecular weight and dimension, and position of substitutes within molecule are important factors.—*R. E. Thompson.*

Step-Photometric Microanalysis of Drinking and Industrial Water. VIII-IX. CARL URBACH. Mikrochemie, **14**: 189–218, 1934; cf. C. A., **27**: 4327. From Chem. Abst., **28**: 3153, May 20, 1934. Step-photometric methods described and comprehensive tables given for determination of phosphoric and silicic acids. Methods are based upon formation of blue complexes of reduced phosphomolybdic or phosphosilicic acids. Former complex is less stable than latter. By heating 3.5 minutes on water bath at 70°, blue color due to reduced phosphomolybdic acid disappears while that of corresponding silicon complex remains. This fact permits easy determination of both. On basis of prior work of TSCHOPP and TSCHOPP (C. A., **26**: 5112), silicic acid can be determined in presence of phosphoric acid by destroying yellow phosphomolybdate complex with 5 cc. 4 percent oxalic acid solution and phosphoric acid can be determined in presence of silicic acid by adding 5 cc. 7 percent sodium bisulfite solution before adding molybdate reagent, which prevents formation of silicomolybdate, but not of phosphomolybdate.—*R. E. Thompson.*

Treating Liquids with Gases as in the Treatment of Water or Sewage with Chlorine. WILLIAM H. FULTON (to Paradon Co.). U. S. 1,949,934, March 6. From Chem. Abst. **28**: 2956, May 20, 1934. Details of apparatus and operation.—*R. E. Thompson.*

Apparatus for Chlorinating Water. Wallace and Tiernan Products, Inc. Ger. 590,805, January 12, 1934 (Cl. 12i. 4). From Chem. Abst., **28**: 3158, May 20, 1934.—*R. E. Thompson.*

The Influence of Phosphate Buffer on the Acid Fermentation of Glucose by Escherichia Coli, V. CIANCI. Boll. soc. ital biol. sper., **8**: 1694–8, 1933. From Chem. Abst., **28**: 3099, May 20, 1934. Acid fermentation by *Es. coli* in

NAEGELI glucose medium was studied in presence of decreasing amounts of phosphate buffer at both 25° and 37° incubation for 10 days. Results show that increasing amount of buffer (KH_2PO_4-Na_2HPO_4) caused increase in growth, in velocity of growth, in amount of acid formed, and in gas formation. Residual unfermented sugar was minimum in cultures having highest concentration of buffer. **The Influence of Veronal-Acetate Buffer on the Acid Fermentation of Glucose Caused by Escherichia Coli.** Ibid., 1698–1701. Veronal-acetate buffer was compared with phosphate buffer previously described. Since MICHAELIS buffer has weaker buffering action than phosphate buffer within limits of pH and concentration used, results show that (*a*) buffer action of culture medium is principal regulator of acid fermentation of glucose by *Es. coli*; and (*b*) increasing amount of buffer increases velocity of reaction and amount of acid produced.—*R. E. Thompson.*

Decay and Repair of Concrete and Masonry Dams. B. HELLSTROM. Structural Engr., 11: 210–28, 1933. From Chem. Abst., 28: 3209, May 20, 1934. Water percolating through dams causes disintegration through first leaching out free lime and then breaking down hydrated calcium compounds. Effect becomes more serious as pH of water decreases. Repair can best be effected by application of 1:1 cement-sand mortar over whole upstream face.—*R. E. Thompson.*

A Critical Study of Boiler Scales and Advanced Methods of Analysis and Identification. SHEPPARD T. POWELL. Combustion, 5: 3, 15–19, 1933. From Chem. Abst., 28: 3154, May 20, 1934. Scale formation and scale analysis discussed. Chemical methods are not adequate because they do not permit accurate identification of complex crystalline deposits occurring in high-pressure boilers. Petrographic analysis provides satisfactory identification.—*R. E. Thompson.*

Plastic Flow of Portland Cement Concrete. J. R. SHANK. Ind. Eng. Chem., 27: 9, 1011–4, 1935. Plastic flow of concrete is defined as continuance for an appreciable time of increase of deformation due to sustained stress, or decrease of stress during sustained strain. Empirical formula is deduced. Effects of different aggregates, of special cements, and of stress, and applications to stresses in reinforced concrete are discussed.—*Selma Gottlieb.*

Portland Cement and Its Possibilities. R. W. CARLSON. Ind. Eng. Chem., 27: 9, 1014–6, 1935. Manufacture of Portland cement is described briefly. Because of properties of brittleness and volume change in concrete, only small proportion of tensile strength can be used. Major factors influencing volume change and control of this property are discussed.—*Selma Gottlieb.*

Structural Properties in Gypsum. CLARKE F. DAVIS. Ind. Eng. Chem., 27: 9, 1017–9, 1935. Structural gypsum is now available as Gypsteel Planks 2 inches x 15 inches x 6 or 10 feet, with core reinforced with wire mesh. Sides and ends are bound and reinforced with tongued and grooved galvanized, copper-bearing-steel channels 2 inches deep. Usefulness depends on flexibil-

ity, ease of application, fire-resistance, insulating properties, lightness, and resistance to many acid fumes and to termites.—*Selma Gottlieb.*

Calcium Hydrosilicate as a Building Material. F. O. ANDEREGG. Ind. Eng. Chem., **27**: 9, 1019–21, 1935. Product is made by steam cooking of emulsion made from finely divided silica (200 mesh), lime and water, followed by firing, and is called Microporite. Usefulness depends on lightness (apparent specific gravity, 0.4 to 0.8), strength per unit weight, insulating and sound-deadening properties, and fire resistance. For direct exposure to weather, surface of Microporite must be protected, as by Morbelli cement sheeting, a special asbestos-cement product.—*Selma Gottlieb.*

Classification of Brick by Water Absorption. WALTER C. VOSS. Ind. Eng. Chem., **27**: 9, 1021–3, 1935. Although observed variations in absorption properties are not completely understood, some generalizations may be drawn as to internal structure and quality of brick samples from results obtained.—*Selma Gottlieb.*

Rostone Operations. R. L. HARRISON, P. W. JONES and R. NORRIS SHREVE. Ind. Eng. Chem., **27**: 9, 1023–6, 1935. Rostone is made from reaction of naturally occurring aluminosilicates, such as shales and slates, with an alkaline earth base in presence of low-pressure steam. Present manufacturing procedure is described, including use of fly ash from powdered coal combustion as siliceous ingredient. Fly ash yields product of good physical qualities for construction material, offering solution to fly ash waste problem.—*Selma Gottlieb.*

Protective Films on Ferrous Alloys. FLORENCE FENWICK. Ind. Eng. Chem., **27**: 9, 1095–9, 1935. Electrometric titration with chloride solution is proposed for determining relative permeability of protective films on ferrous alloys. Results obtained show general parallelism between amount of chloride required to cause breakdown of film and general experience as to relative resistance to corrosion of ordinary carbon steel, copper-bearing steel, and stainless steels; but author stresses need for further work.—*Selma Gottlieb.*

Absorption of Water by Portland Cement Paste during the Hardening Process. T. C. POWERS. Ind. Eng. Chem., **27**: 7, 790–4, 1935. When Portland cement hardens, volume of system cement-water decreases. This does not necessarily require diminution in dimensions of hardened paste, since solid phase expands simultaneously with reduction in total volume of both phases. Absorption of water by submerged pastes at nearly constant temperatures is controlled by chemical composition and water-cement ratio. It is influenced by same factors that govern heat of hydration, but relationship is not clear. *Selma Gottlieb.*

Corrosion of Steel. THOMAS J. FINNEGAN, RICHARD C. COREY and DAVID B. JACOBUS. Ind. Eng. Chem., **27**: 7, 774–80, 1935. Definite concentrations of dissolved oxygen and carbon dioxide were maintained for 21-day periods

in water flowing continuously over Bessemer steel wire samples at 2.5 cm. per minute (viscous flow) at 60°C. ±5°. Corrosion rate was found to be function of concentrations of both dissolved gases; but one p.p.m. of oxygen is approximately as corrosive as 20 p.p.m. of carbon dioxide. At zero concentration of either gas, corrosion rate is not zero, but depends on concentration of other gas. In certain heating-system installations, trapping of non-condensable gases ahead of condensate causes solution of excess amounts, therefore increasing corrosion.—*Selma Gottlieb.*

"Classing" of Ferrous Products. RAYMOND R. ROGERS. Ind. Eng. Chem., **27**: 7, 783–9, 1935. New electrochemical method of coating ferrous materials with stainless, high-carbon, or high-speed steel, nickel, or stellite, is described. Plates of coating material are given anodic pickling and electrolytic iron coating, followed by welding. The composite is backed with cheap ferrous material by rolling, electrolytic iron being in center. Photomicrographic studies show excellent welding obtained.—*Selma Gottlieb.*

The Soap and Detersive Industry. MARTIN HILL ITTNER. Ind. Eng. Chem., **27**: 7, 756–8, 1935. Alkaline "builders", originally added to soaps for economic reasons, have been found to yield superior household detergents at lower unit cost, especially for hard water regions. "Dry saponification" of dry fats and anhydrous alkaline materials with superheated steam is new development giving rapid production of anhydrous soap and concentrated glycerol. Author considers displacement of any large proportion of soap by sulfate, or sulfonate, cleansers as unlikely.—*Selma Gottlieb.*

Bin Shapes and Feeders. HARLOWE HARDINGE. Ind. Eng. Chem., **27**: 11, 1338–41, 1935. Proper bin shapes, with precautions against segregation and bridging, are described, which minimize feeding difficulties; but variation in volumetric feeding usually ranges between 20 and 30 per cent in weight. A simple and inexpensive belt device for continuous feeding by weight, which is described, eliminates this fluctuation.—*Selma Gottlieb.*

Compounds in Portland Cement. R. H. BOGUE. Ind. Eng. Chem., **27**: 11, 1312–6, 1935. Identification of chief compounds in Portland cement as tri- and dicalcium silicates, tricalcium aluminate, tetracalcium alumino-ferrite, and magnesia has been comfirmed by microscopic and x-ray diffraction methods. Knowledge of properties of individual compounds gives basis for production of cements with special characteristics desired, e.g., quick strength, low heat, etc.—*Selma Gottlieb.*

The Purification of Water and its pH Value. SAMUEL B. ELLIS and SAMUEL J. KIEHL. Jour. Am. Chem. Soc., **57**: 2145–9, November, 1935. Starting with once-distilled water, best results were obtained by distillation from phosphoric acid in still, permitting aëration in both boiler and condenser. pH of best sample, collected in silver vessel, was 7.01 at 27.5°C., by direct measurement with glass electrode.—*Selma Gottlieb.*

Studies in Microbic Dissociation. II. Changes in the Biological Characters of Shigella paradysenteriae During Dissociation and Partial Reversion. G. M. MACKENZIE, HELEN FITZGERALD and VERNAL IRONS. Jour. Bact., 29: 6, 583–594, 1935. A stabilized rough variant of *Shigella paradysenteriae* Flexner was obtained by growing a smooth culture in formalin broth. It differed in serological, morphological and physiological characteristics from parent culture. By several changes in environmental conditions, favoring reversion, four distinct reversion cultures were produced, all differing in one or more biological characteristics from both predecessors. Agglutinative, agglutinogenic, and absorptive capacities of *Shigella paradysenteriae* Flexner may vary independently of each other as result of dissociation.—*Selma Gottlieb.*

Application of Statistics to Problems in Bacteriology. IV. Experimental Comparison of the Dilution Method, the Plate Count, and the Direct Count for the Determination of Bacterial Populations. N. R. ZIEGLER and H. O. HALVORSON. Jour. Bact., 29: 6, 609–34, 1935. Experiments were made to check theoretical considerations in three previous papers by same authors. Plate and dilution counts gave concordant results on pure cultures of *E. coli*, *B. subtilis*, and *S. aureus*, but not on *Ps. pyocyanea*. If clumps of bacteria are thoroughly broken up and cultures have not entered death phase, direct count also checks plate and dilution methods. Mixed cultures of *E. coli* and *Ps. pyocyanea*, *E. coli* and *S. aureus*, and mixed flora from packing house pickle were also studied. Dilution method gives new approach to study of bacterial antagonism. Authors believe agreement of dilution method with others justifies use of POISSON'S series for development of fundamental equations in their previous papers.—*Selma Gottlieb.*

Studies of Freshwater Bacteria. II. Stalked Bacteria, a New Order of Schizomycetes. ARTHUR T. HENRICI and DELIA E. JOHNSON. Jour. Bact., 30: 1, 61–94, 1935. Study of periphytic bacteria on glass slides submerged in freshwater habitats showed general occurrence of group of bacteria which secrete stalks as attachment to firm substrate. Older bacteriological literature contains descriptions of similar types. Authors propose new order of Schizomycetes, the Caulobacteriales or stalked bacteria, with four families and five genera, for which key is given. With eighteen sketches and four photomicrographs.—*Selma Gottlieb.*

Stimulation of Bacterial Growth Rate by Methyl Germanic Oxide. PHILIP L. CARPENTER, MACDONALD FULTON and C. A. STUART. Jour. Bact., 30: 2, 137–42, 1935. Cultures of various organisms, including *Esch. coli*, *A. aërogenes*, and *Eb. typhi*, in nutrient broth containing 0.01 M methyl germanium oxide were found:—(1) to be inhibited during lag phase; (2) to be stimulated during early logarithmic phase; and (3) to show premature period of decline; as compared with cultures in nutrient broth alone.—*Selma Gottlieb.*

Some Observations on the Germicidal Efficiency of Chloramine-T and Calcium Hypochlorite. DAVID B. CHARLTON and MAX LEVINE. Jour. Bact., 30: 2, 163–71, 1935. With both chloramine-T and calcium hypochlorite, pH

was most important single factor affecting germicidal activity against bacterial spores used, even considering effects observed by varying temperature or disinfectant concentration with other variables constant. Available chlorine (AC) was not found direct measure of germicidal efficiency of calcium hypochlorite used. Solution containing 1000 p.p.m. AC at pH 11.3 was only slightly more germicidal than same solution diluted to 100 p.p.m. AC at pH 10.4, and very much less efficient than 20 p.p.m. of same disinfectant at pH 8.3—*Selma Gottlieb.*

Water Show for Public Staged at San Diego, Cal., Exposition. Anon. Water Works Eng., **88**: 17, 956, August 21, 1935. City of Los Angeles building at the Exposition, aptly designated as the "Water Palace," is an excellent exhibit of the development of that city's water supply. An attendant describes the great water projects of Southern California, while the panorama graphically shows the lakes, reservoirs, aqueducts, and irrigation systems.—*Lewis V. Carpenter.*

When are Water Tax Laws Valid? LEO T. PARKER. Water Works Eng., **88**: 17, 937, August 21, 1935. A city ordinance is valid and enforceable which pledges, as security for water bonds, profits to be derived from future operation of its plant; but, if present operations of the plant show small or no profits, and bond debt cannot be reasonably secured from other sources, an ordinance of this nature is void. Another important point of law is, that if a state law, as usual, requires city tax ordinances to specify in detail the purposes of levies, an ordinance is void which stipulates a lump sum to be used for more than one purpose. Author cites one case where ordinance passed by a Municipal Council for issuing bonds for purposes of "acquiring or constructing" water works was ruled by court as legal; while in other cases, resolutions declaring the necessity for issuing bonds "for the purchase and erection of water works" were held illegal. Courts have held that municipalities can accept Federal loans for water works construction, in spite of fact that existing state laws might be held unconstitutional. They have also held that a municipality cannot incur a valid indebtedness without assent of the voters, if such incurrence violates valid provisions of state law. It is well settled law that a water company which sells its water system to a municipality is not relieved from payment of taxes levied upon the gross receipts, notwithstanding that company would be relieved from taxation if plant were sold to a private corporation, or, that the municipality, to which the plant is sold, is exempt from taxation.—*Lewis V. Carpenter.*

Increasing the Efficiency of a Small Water Plant. WILLIAM S. STAUB. Water Works Eng., **88**: 18, 982, September 4, 1935. A young college student who went out as superintendent of a one-man water department lists his experiences in learning to handle the public and keep things moving. Plant supplies 255 customers and superintendent has to pump and chlorinate water, make service connections and repairs, read meters, make out bills, and collect. Author cites 9 rules which he has followed and found helpful.—*Lewis V. Carpenter.*

The Market is Ripe for Water Securities. R. EMERSON SWART. Water Works Eng., **88**: 18, 980, September 4, 1935. There has been no record of default for the last 25 years upon mortgage bonds of a major operating company in water works field. The prevailing low interest rates combine with the popularity of this type of security to afford an unusual opportunity for owners of water works properties to reduce their fixed charges. Author cites several important bond refundings that have effected substantial reductions in interest.—*Lewis V. Carpenter.*

French Artistry Exhibited in Paris Well Supply. R. S. CHARLES. Water Works Eng., **88**: 19, 1052, September 18, 1935. Paris in the last four years has developed 90,000,000 gallons per day from ground water sources. The wells are from 300 to 2800 feet deep. Deeper wells are from the historic source of water found at Artois, whose flowing wells gave us the name "artesian." The characteristic French attitude toward the aesthetic appears in landscaping of the well fields, and in design of well houses, receiving reservoirs, and pumping stations.—*Lewis V. Carpenter.*

Water Purification in New England. E. SHERMAN CHASE. Water Works Eng., **88**: 19, 1056, September 18, 1935. Purification of public water supplies has not been adopted in New England to same extent as in other parts of the country. The extraordinary use of the automobile and the extension of excellent highways across sparsely settled watersheds has brought about a very materially increased hazard of contamination of surface supplies. Consumers of soft, but colored, New England surface waters are no longer satisfied when occasional unpalatable tastes and odors occur. Regional sentiment is against rapid sand filters and chlorination. Use of copper sulfate for control of algae is quite common, but use of ammonia, activated carbon, and chlorine has not been viewed with favor. A few plants are adjusting pH value for prevention of corrosion. Author lists the supplies of the various New England states, only 41 percent of which receive treatment and 30 percent, only chlorination. Typhoid fever record of the New England states has constantly been below that of any other main subdivision. The success in combating typhoid can be attributed to the early recognition of the health hazard, and the adoption accordingly of suitable protective and preventive measures. —*Lewis V. Carpenter.*

Journal of the New England Water Works Association, Vol. 49, No. 3, September 1935. Report of Committee on Pipe Line Friction Coefficients and Effect of Age Thereon. ELSON T. KILLAM, Chairman, FRANK A. BARBOUR, W. W. BRUSH, LAURENCE C. HOUGH, CHARLES W. SHERMAN. 235-342. Primary purpose in preparing report has been presentation of hitherto unpublished data upon friction coefficients of tar-coated cast-iron pipe, with particular reference to age-coefficient relation and to effect of water quality upon rate of capacity loss. From questionnaires and other available data, Committee has drawn following major conclusions: (1) average actual loss in capacity of tar-coated cast-iron pipe of 20.5-inch average diameter after 30 years of service (473 tests in 19 different systems) was 52 per cent as against

predicted loss of but 32.3 per cent; (2) based upon data available, WILLIAMS-HAZEN age-coefficient relation is applicable primarily to large diameter mains carrying relatively inactive water; (3) for small diameter mains carrying active water, actual loss after 30 years may be twice the WILLIAMS-HAZEN-predicted loss; and (4) other factors being equal, data showed marked correlation between pH of water and rate of capacity loss, average loss at pH 6.5 being twice as great as at pH 8.0. Trend curves for generalizing age-coefficient relation are presented only where numerous tests of reasonable accuracy were available. Capacity, rather than structural integrity, is usually controlling factor in useful life of cast-iron pipe. Economic loss due to reduced carrying capacity caused by tuberculation, incrustation, slime, or silting, may warrant cleaning of mains followed by some method of lining in place. Importance of determining capacity trends in each city cannot be over-emphasized. This comprehensive report, however, is not confined to tar-coated pipe. Additional subjects covered include: coefficient values of pipe with cement, bitumastic-enamel, and miscellaneous linings; "Tate" process for lining small mains in place with cement; corrective water treatment for reduction of corrosion; and restoration of capacity of unlined cast-iron pipe by cleaning. In appendices are list of contributors, questionnaire forms circulated by Committee, coefficient values for steel and concrete pipe, various tests affording direct comparison of coefficient values for different types of pipe, and effect of velocity on values of WILLIAMS-HAZEN coefficient. While there exists theoretical basis for fact that value of WILLIAMS-HAZEN C is slightly affected by magnitude of velocity obtaining during test, such effects are negligible in comparison with more important factors of precision of measurement. Data available are still too limited to permit of definite conclusions, but indications are that pipe lined with cement, or with bitumastic-enamel, centrifugally applied, sustain carrying capacities far better than tar-dipped pipe. Though cleaning tar-coated pipe will ordinarily restore 85 per cent of original capacity, subsequent maintenance of restored capacity may vary from several years to as low, in case of small mains, as 4 to 5 months. To prevent this rapid deterioration, "Erie" process for depositing bitumen lining electrically, and "Tate" process for cement-mortar lining have been developed in England for lining small mains in place. Equipment is also available for centrifugal application of cement lining to large mains after cleaning. Mass data collected, but not included in printed report, have been placed on file in Engineering Societies' Library, 29 West 39th St., New York City.—*T. F. Donahue.*

Journal of the New England Water Works Association, Vol. 49, No. 4, December 1935. Fire Service Charges. H. E. HALPIN. 345–353. Studies made in 1910 revealed that, for cities of 100,000 population, 20 to 25 percent of entire cost of water works plant is necessitated by fire protection requirements. For towns smaller than 10,000, percentage may run as high as from 60 to 80. Recent questionnaire replies indicate that average annual revenue charged on "hydrant rental" basis by municipally or privately owned water works for public fire service is $37 per hydrant. Systems making no charge are not included in average. While state utility commissions have ruled that water works should receive revenue for public fire protection, difference of opinion

exists concerning payment of revenue for private fire protection (sprinklers, etc.), when user has already paid for same through his taxes. In general, consumer pays entire cost of installation of sprinkler connection from public main to property line. While two-thirds of municipally owned systems make no annual charge for connections serving automatic sprinkler equipment, private hydrants, or standpipes, practically all private systems make charge. Amount for 6-inch connection may vary from $27.50 to $474.00 per year, or when based upon sprinkler heads, from $0.02 to $0.18 each. **How to Make Cross Connection Surveys?** WARREN J. SCOTT. 354–359. Connecticut State Department of Health policy is given as one answer to question above. Separation of private drinking-water supplies from public is recommended, but not required, if private supply tests safe. Public water-supply management can insist on physical separation on grounds that it had no jurisdiction over private supply. First task in cross-connection survey is to locate all auxiliary supplies. Most frequently encountered cross-connections, aside from plumbing connections, are: industrial process water supplies, auxiliary fire supplies in industrial plants, pump priming lines, auxiliary boiler feed lines, and private well supplies used for drinking or other purposes. Properly maintained double check-valves may serve useful purpose in event that cross-connections are inadvertently made inside factory or mill; but state policy is to permit no new cross-connections, even though protected by double check-valves. Danger of dual system to factory workers is stressed. **Water Rates.** EDWY L. TAYLOR. 360–365. Chairman of Connecticut Public Utilities Commission reports more complaints on rates for water than on those for other public utility services. Rates must be adjusted to protect alike interest of public, utility investor, and manager of utility involved. Financial results from operation of water properties may be compared to those from contract on "cost plus" basis. There should be no free water, as this must impose upon other customers unfair and discriminatory rates. **Recent Extensions of the Water Supply of Geneva, Switzerland.** A. BÉTANT. Translated from the French by GORDON M. FAIR. 366–371. Gradual growth of distribution system to cover 34 communities with total population of 150,000 has engendered difficulty in maintaining equable pressures. Tendency is for water to be drawn into low-lying portions of system to detriment of high-lying areas. Differences in elevation of 525 feet necessitate use of booster pumps. Irrigation causes seasonal per capita consumption to vary from 90 to 185 g.p.d. Rather than increase capacity of station at Coulouvrenière, which draws its supply from Lake Geneva, auxiliary pumping stations, each with its independent supply, were established on periphery of network. Installation of new large diameter mains was thus avoided. The first two auxiliary stations draw their supplies from lake; subsequent ones, from deep wells. Total capacity was increased from 23.7 to 30 m.g.d. **Joint Use of Service Trenches for Different Utilities.** LEON A. GOODALE. 372–375. Experiences cited at Worcester, Mass., prove that unless sole and absolute authority is vested in one party, joint occupancy of service trenches is impracticable. **Emergency Work of the Division of Sanitation During the New York State Flood of 1935.** ANSELMO F. DAPPERT. 376–394. Despite entrance of sewage-polluted flood waters into several municipal water supplies, no epidemic of disease followed catastrophe. Unofficial reports gave

rainfall in excess of 8 inches in 24 hours in cloudburst which took place on July 7-8. Damage wrought was tremendous. Filter plant at Delhi was partially washed away, 80,000-gallon settling basin being floated 1500 feet downstream. Pipe lines under rivers were broken, rivers reversed their flow, sewage was brought to intakes, pumping station motors were put out of service by rising waters, and roads, walls, pipe lines, and tunnels were washed away. State Health Department Engineers helped to install portable emergency chlorinators and hypochlorite treatment plants in 16 communities. Existing chlorination and water treatment plants were checked and re-checked for possible contamination. Work was then centered on private water supplies. With aid of C.C.C. and U. S. Soil Erosion Service, 10,000 private wells were treated with strong solutions of chloride of lime. While primarily concerned with water supplies, engineers aided in general sanitation, removal of dead animals, mosquito control, disinfection of basements, etc. At Walton, engineers supervised systematic disinfection of entire distribution system in area flooded. Meanwhile public was supplied by delivery service. Outstanding lesson is need for comprehensive program of rural sanitation along educational lines. First requirement in similar emergency is repeated warnings to "boil all water." **Gates and Hydrants.** THOMAS E. LALLY. 395–398. In Boston, hydrants in congested districts are spaced 250 feet apart and so located as not to interfere with doorways, driveways, or large show windows. In residential districts, hydrants are not over 300 feet apart. All hydrants should be gated. **Recent Developments in the Providence Water Works.** PHILIP K. HOLTON, Jr. 399–405. To make water supply from new Scituate Reservoir available for fire protection and consumer service, comprehensive water-works extension program was started in 1933. Plan involved laying of over 22 miles of pipe, from 6 to 26 inches, to furnish additional capacity in low-service system, particularly for city of Warwick, where growth has been most rapid, and to reinforce high-service area by providing additional protection for high-valued fire district. Eliminating 238 dead ends should reduce "red water" complaints to minimum. Inadequacy of 48-inch Neutaconkanut low-service line to supply Bath Street pumping station, and potential hazard to fire protection in high-service should break occur in single line led to erection of new 11½-m.g.d. station adjacent to Neutaconkanut Reservoir. Old station retains 2 gasoline-engine-driven pumps ready for service with 2 motor-driven units available when power line is connected. Reforestation program has proven of sufficient value to warrant establishing nursery. **Providence Water Treatment.** ELWOOD L. BEAN. 406–418. Raw water is drawn from point in Scituate Reservoir 60 feet below surface and 20 feet above bottom, for three reasons: (*a*) to take advantage of natural coagulants in solution in chosen stratum, (*b*) to avoid growths of microörganisms in upper strata, and (*c*) to deliver water of lower temperature to consumers during summer. Although concentration of blue-green algae may be sufficient in June to impart color to surface water and to give off odor, no treatment of reservoir is practised and only once have organisms been present in sufficient numbers to cause trouble. Treatment consists of addition of anhydrous ferric sulphate, aëration, lime treatment, mixing, coagulation and sedimentation, filtration, and secondary aëration. Need for removal of manganese forced change from alum to ferric sulphate.

Increasing pH from 6.3 to 9.6 has eliminated colored water. Tests have demonstrated that average amount of iron picked up by water at pH 9.6 is but one-tenth as much as at pH 7.6; while average increase in lead content is but one-fourth. Owing to high bacterial quality of raw water, chlorine is required only for small fraction of time. Rarely occurring persistence of taste and odor after secondary aëration was remedied by activated carbon, applied to settled water just before filtration. Filter runs were reduced to one-half and one-third of normal, respectively, by addition of 0.4 and 0.6 p.p.m. of carbon. **Recent Progress in Supplying Less Corrosive Soft Water.** MALCOLM PIRNIE. 419–427. Early in use of rapid sand-filters for purifying soft waters from rivers and impounding reservoirs for municipal water supplies, deterioration of water from filter to consumer was considerable. Accelerated rusting and clogging of pipes with accompanying red water, odors in dead ends, and increased lead in solution were all charged against filtration. Soft water delivered to existing distribution systems in which large proportion of pipes are cast-iron should be of highest possible degree of stability. Water in contact with iron, or with lead, of house plumbing should have following characteristics: (1) pH of 9.6 to 9.8; (2) iron content of 0.05 p.p.m., or less, to prevent deposition of iron hydrate; (3) 0.00 manganese, since manganese will precipitate as black mud at high pH; (4) aluminum content not greater than 0.03 p.p.m.; (5) low temperature to increase potability and to inhibit bacterial activity; and (6) residual chlorine content of 0.02 p.p.m. to prevent bacterial after growths With high pH, zinc, which is highly soluble in hot or cold water at pH of 9.7, should be avoided in favor of more resistant lead, iron, or copper.—*T. F. Donahue.*

NEW BOOKS

Das Wasser in der Industrie und im Haushalt. J. LIECK, Chemist, Duisberg-Muendelheim. 118 pp., 36 figs., 1935. Fortschritte der Chem. Technologie in Einzeldarstellung. Vol. 33. Pub. Prof. Dr. B. Rassow, Leipzig. This volume has as its purpose the assembling of the details of a subject which is scattered through many periodicals and the presentation of that knowledge in a treatise which spans the broad field of water quality without neglecting too much detail or omitting theoretical considerations.

The nature, causes and methods of reduction of the more common substances in solution are discussed. The text gives procedures for the quantitative determination of the chemical constituents of water and brief descriptions of treatment processes, including filtration, sterilization, taste removal, hardness, iron and manganese removal and degasification. Short discussions on the effect of the quality of water for household and industrial purposes are included. The latter half of the book deals with water used in steam power boilers and the discussion of the treatment of water for boiler feed use is thorough. Special emphasis is given, of course, to hardness, CO_2 and free oxygen reduction.

Unlike most formal German writing, the style is easy and direct. The subject is presented with the necessary simple chemical equations. The book is of value to the waterworks operator who desires a broad picture of the principles of water chemistry and the effect of water quality on industrial operation. The volume should interest also the power plant operator who wishes

some knowledge of water chemistry in its relation to feed water treatment and boiler performance.

In some respects, this book may be regarded as a handbook on elementary water chemistry, although neither the form nor the treatment is similar to the typical American handbook. The latter is the result of American engineering technic which achieves production under pressure. The average American handbook is so choked with formulas, constants and technical short-cuts that it must ignore the theory of its field. The thoughtful person cannot disregard the tendency which such books might have to deter more thorough individual understanding of their subject matter.

On the other hand, a book such as this one, which has as its purpose the assembly of the essentials of a subject and the presentation of those essentials in concise, readily usable form with adequate treatment of theory is of undoubted value.—*P. Charles Stein.*

Die Welt der Bakterien. DR. HANS LEHMANN, Prof. Hygiene, University of Jena, Member of the Prussian State Institute of Water, Soil and Air Hygiene. 172 pp., 79 figs., 1931. Pub. Leopold Voss, Leipzig. This is essentially a presentation of the fundamentals of bacteriology and bacterial hygiene for the lay reader. At the same time it is by no means a popular digest, since neither technical accuracy nor method has been sacrificed to sweeten the task of learning. The author's purpose is to provide a brief text for non-medical students, university extension students and such other persons who might be interested in the subject.

Rather than concern itself with minute details of the morphology and biology of micro-organisms, the book allots a minimum of space to bacteriology proper and devotes its major part to the broader fields of the nature, causes, transmission and prevention of epidemic diseases.

The first part of the book sketches the historical development of bacteriology, discusses the major classifications and describes the culture, staining and examination of bacteria. A chapter is devoted to the activities of various micro-organisms, outlining the more common fermenting and putrefying organisms and their biologic and chemical processes.

The latter half of the book is allocated to the practical aspects of bacteriology in relation to the contamination of foodstuffs and the transmission and control of communicable diseases. This section includes information on the sources of infection of the more contagious diseases and the effect of vaccines and other measures in reducing their incidence and mortality. Sufficient tabular and graphical statistics are presented to illustrate the text.

In addition to an index, the book is provided with a complete glossary of technical terms used in the text as well as a short description of each of the investigators whose names are mentioned—*P. Charles Stein.*

Long Versus Short Body Fittings for Water Supply. Cornell University Engineering Experiment Station Bulletin No. 20. 102 pp., $1.25. Cornell University Press. Ithaca, N. Y. Part I of this report covers very thoroughly a series of tests, made for the Sectional Committee on Cast Iron Pipe, by Professors Ernest W. Schoder and Arthur N. Vanderlip, on Friction Loss Through

Cast Iron Pipe Fittings, some of the fittings tested being the present AWWA standard and the others of proposed short body types.

Part II of this bulletin is entitled "Economic Comparison Considering Operating Cost, as Affected by Friction, and Installation Cost," by Messrs. Allan T. Ricketts and Thomas H. Wiggin, the latter the chairman of the Sectional Committee. This is an application of the results of the Cornell tests to the hydraulics of a typical water distribution system, for both domestic and fire flows, and a similar application to pumping station headers.

This bulletin is the second of six being prepared by or for the Sectional Committee on Cast Iron Pipe, these six bulletins to cover tests made for this committee by six American universities.

The first bulletin issued was Ohio State University Engineering Experiment Station Bulletin No. 87 entitled "Investigation of Bell and Spigot Joints in Cast Iron Water Pipes" by Prof. John C. Prior. Ohio State University, 50 cents.—*A. V. Ruggles.*